AGRICULTURAL ENGINEERING

AUGUST • 1955

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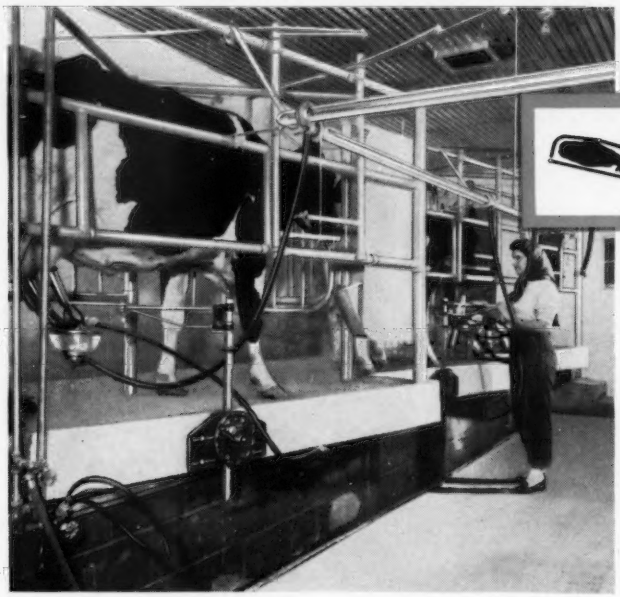
CASE "400"

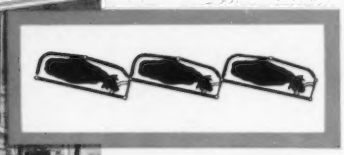
A Diesel That Starts Right on the Button

Just push a dust-sealed button and the 12-volt starter brings the Case "400" Diesel to life, directly on diesel fuel. No extra engine, no extra fuel, no preliminaries. It's as simple as that, thanks to the Case Powrcel Controlled Combustion system that not only makes direct starting swift and sure, but also provides smooth operation at all speeds and loads. This is one more sample of what advanced engineering can achieve . . . of how exacting research emerges as an every-day benefit to the farmer.

But—this achievement is only one of many breath-taking features that make the Case "400" the finest tractor in the 50-horsepower class. Get the whole story by viewing the new sound, full-color, 10-minute movie, "The New Case '400' Tractor" and the new sound-slide film, "Building America's Finest Diesel." Both are available for loan from your Case dealer or by writing to the J. I. Case Co., Racine, Wis.

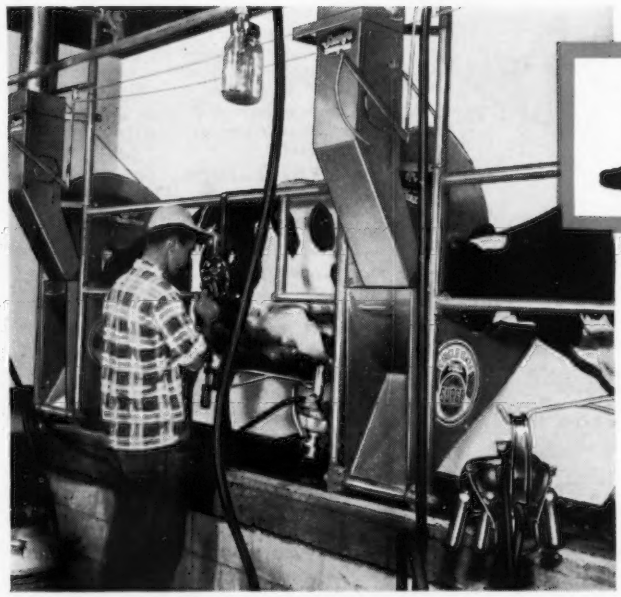
BOTH are built by SURGE

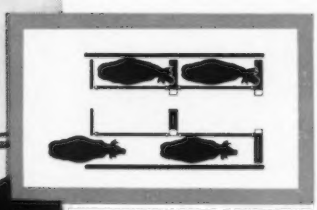




Surge DIAGONAL Milking Stall

The Surge Diagonal Stall, first sold in 1935, is now widely used by dairymen all over the world. Built of finest high-carbon steel for the greatest possible strength and longest life, it is specially designed to handle your herd — no matter what breed you may have — so you get the very best milking job.





Surge CIRCLE-GATE Stall

This is the new member of the Surge Parlor Stall family — built to give all the strength and long life for which all Surge Stalls are known — and designed especially for the dairyman who wants his cows to walk in a straight line through his milking parlor.

With the Circle-Gate stall and feed box, you can now let out two cows . . . put in two new cows and feed them without taking a single step.

Write TODAY for your Surge Circle-Gate Stall booklet.

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AGRICULTURAL ENGINEERING

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Note: AGRICULTURAL ENGINEERING is regularly indexed by Engineering Index and by Agricultural Index. Volumes of AGRICULTURAL ENGINEERING, in microfilm form, are available (beginning with Vol. 32, 1951), and inquiries concerning purchase should be directed to University Microfilms, 313 N. First St., Ann Arbor, Michigan.

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SUBSCRIPTION PRICE: $4.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to ASAE members anywhere, $3.00 a year. Single copies (current), 40 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

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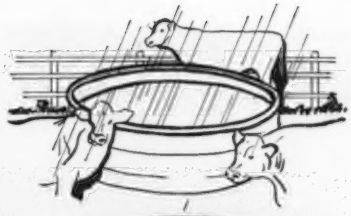
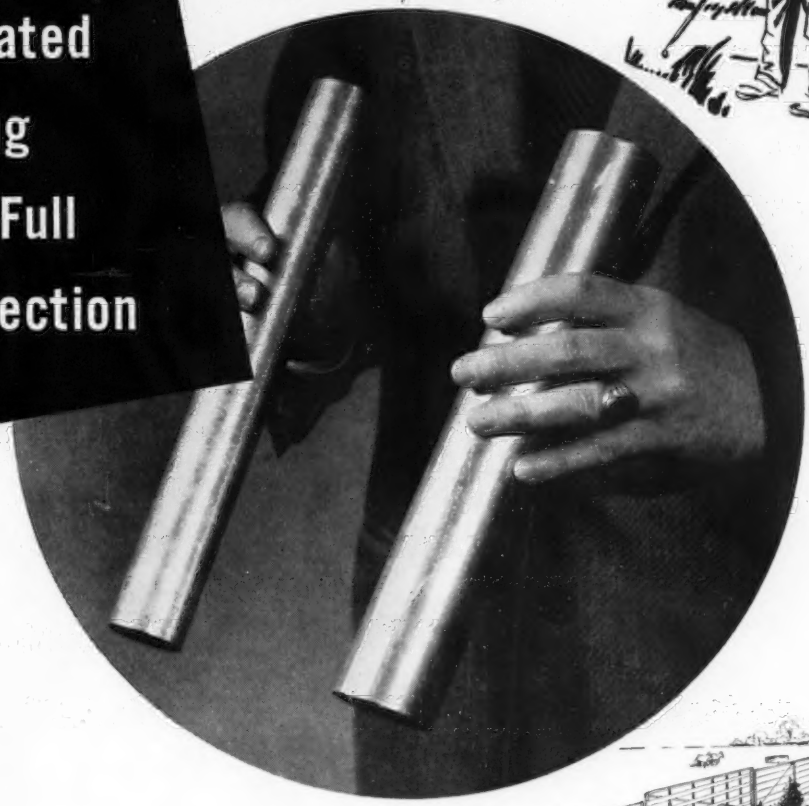
Zinc-Coated Tubing Offers Full Rust Protection





Have you avoided welded steel tubing in designing your farm equipment because you couldn't get the rust protection of a zinc coating? Now you can obtain Armco Steel Tubing made of ZINCGRIP, the special zinc-coated steel that provides unbroken rust protection.

Armco ZINCGRIP Tubing is made from ZINCGRIP strip by the electric resistance welding process. Before emerging from the tube welding machine, the welding flash is planed from the tube and the zinc coating at the seam is replaced on the outside by a special metallizing process. The location of the welded and recoated seam can be found only by careful inspection—it's that smooth.

Available in Many Shapes. This zinc-coated tubing gives you an opportunity to make full use of the advantages of tubular parts in all kinds of farm equipment. It is supplied in rounds, squares, rectangular shapes, hexagons, octagons and special shapes, all with unbroken zinc coatings.

Rounds are produced in outside diameters from ⅝-inch through 3 inches, and in wall thicknesses of 20 gage through 12 gage, depending on size.

Just fill in the coupon for complete information on Armco ZINCGRIP Tubing.

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Call your local CHAIN Belt Man or write CHAIN Belt Company, 4680 W. Greenfield Ave., Milwaukee 1, Wis., for your copy of Agricultural Chain Catalog No. 54-54. Our engineers will be happy to discuss your chain selection and application problems with you.

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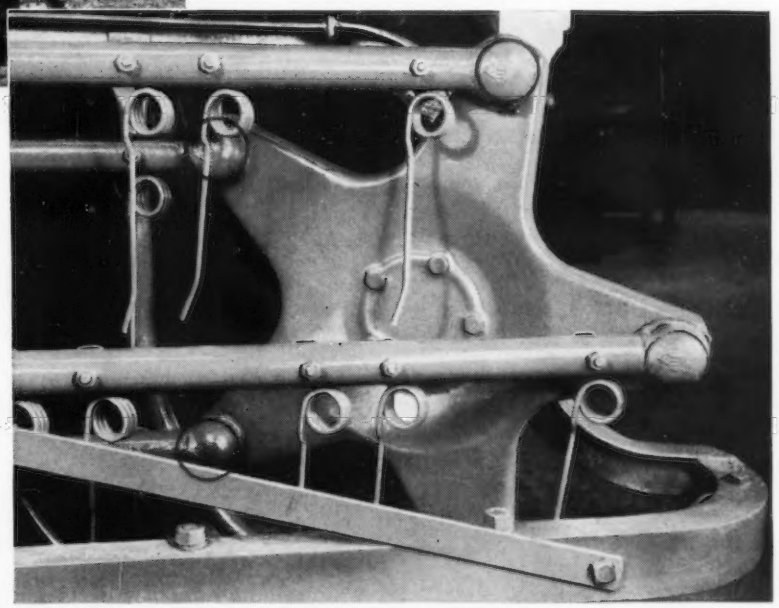
BCA
HAY RAKE BEARINGS
"prove more economical design"

on New Holland ROLABAR Side-Rake

According to New Holland Machine Co.—

"New Holland engineers saw the wisdom of placing a ball bearing at the exact intersection between the center line of the reel tine bar and the spindle on which the tine bar is journalled. This setup reduced friction. Also, one bearing did the work of two at each end of the tine bar. BCA indicated an ability and willingness to make a package unit bearing consisting of a ball bearing with an integral seal and a built-in stud.

"The bearing arrangement proves to be a more economical design, and has worked out very satisfactorily in field service."



The low cost and design efficiency of BCA *package unit* Hay Rake Bearings have attracted wide attention. These pre-lubricated, triple-sealed ball bearings have been thoroughly proved in severe service—in all kinds of weather, under all soil conditions.

If you have a bearing problem, BCA engineering cooperation and design assistance will provide the positive solution.

Closeup showing how BCA package unit bearings are placed at end of tine bars in five-bar reel on New Holland Model 55 ROLABAR Side-Rake. Ball bearings are grease-packed and sealed for life to keep out trash, mud, and water.

If you've got a bearing problem, contact:

BEARINGS COMPANY OF AMERICA

DIVISION OF FEDERAL-MOGUL CORPORATION

LANCASTER • PENNSYLVANIA

Pioneers of pre-lubricated *package unit* ball bearings for agriculture

Torture tests pre-determine performance of V-Belts for rugged cylinder drives

Dayton V-Belts are subjected to grueling lab and field runs to obtain advance proof of endurance and economy.

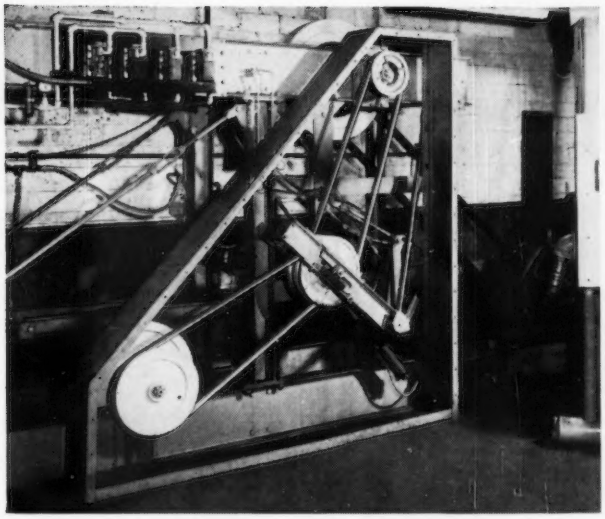
Implement manufacturers specifying Dayton Agricultural V-Belts for all V-drives know beforehand that every type V-Belt has a tested capacity and quality control for meeting maximum drive needs.

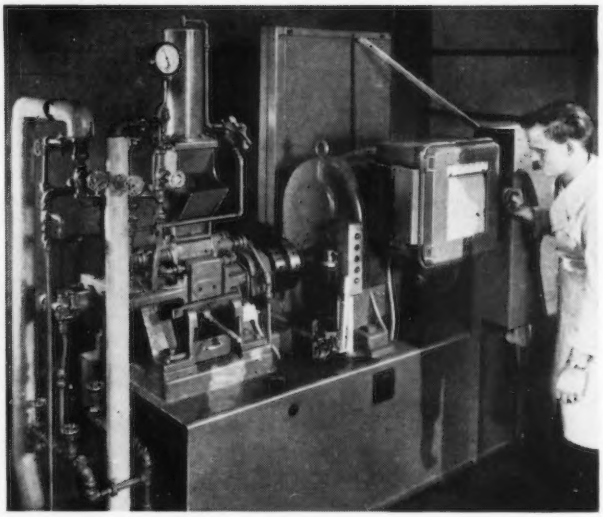
They know Dayton V-Belts will give long, economical performance because each one is a graduate of a series of the most tortuous lab tests ever devised by Dayton Agricultural Engineers. They know, too, the strenuous laboratory punishment dealt out to Dayton V-Belts is followed by field runs designed to duplicate and simulate years of operation under the most rigorous conditions possible.

A good example are the tests applied to Dayton D-Section V-Belts designed and built for combine cylinder drives—the most critical of all implement operations. No mambypamby trials are these to make the V-Belts look good but, instead, the roughest treatment conceivable to try them to the breaking point.

Lab and field results are then correlated to substantiate each other and prove Dayton Agricultural V-Belts, drive for drive, to be the best V-Belt buy on the market for the assurance of long, economical service.

That's why more and more farm equipment manufacturers are specifying Dayton V-Belts as component parts every day. And, why farmers everywhere are glad they do. So for *more* power for *your* money—consult Dayton V-Belt engineers on how to improve your present and future drives with stronger, longer lasting Dayton V-Belts! Dayton Rubber Co., Agricultural O.E.M. Div., Dept. 406, 1500 S. Western Ave., Chicago, Ill.

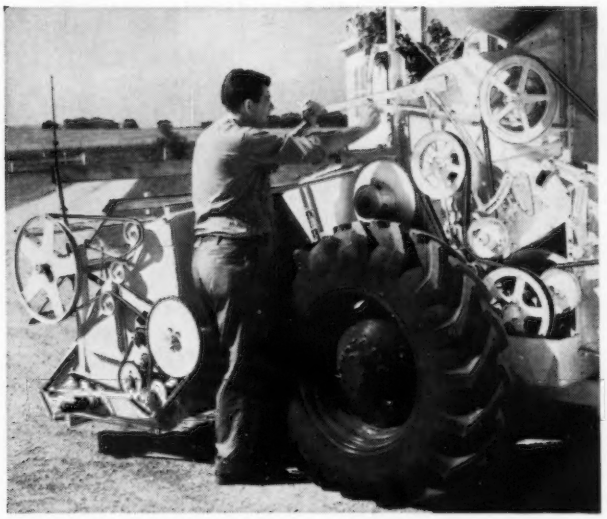


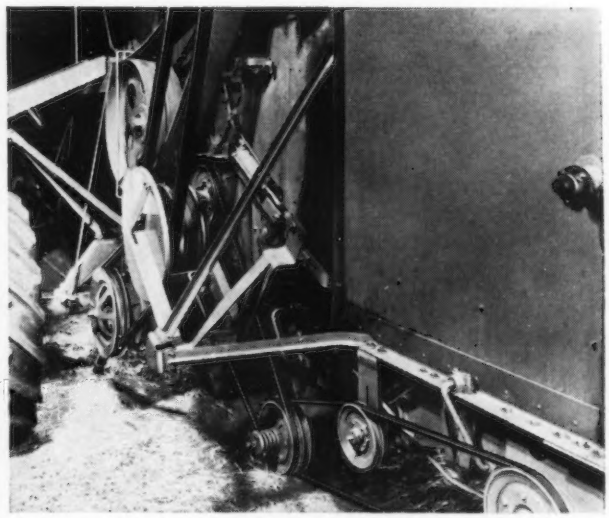


Lab-Tested for Superior Strength and Flexibility

Cylinder drive V-Belts are given full slug load tests on cycling test unit to determine capacity to withstand shock, snap, backlash and heavy pulsation.

Raw materials that go into the production of Dayton Agricultural V-Belts are rigidly laboratory-tested to insure quality control during manufacture.





Field Tested for Endurance and Stamina

Laboratory tests are followed by actual field tests under all conditions of terrain and weather to provide further proof of Dayton V-Belt quality.

Whether on Variable Speed, Back Side Idler or Cylinder drive, Dayton V-Belts give maximum, continuous operation on the drive for which they have been developed.

Pull-Type or Self-Propelled, Daytons outperform all others. Dayton pre-tested V-Belts are top choice for all V-drives on Pull-Type and Self-Propelled combines alike. Because of their amazing tensile strength, Heavy Section Dayton V-Belts are rapidly building up success stories on the rugged self-propelled cylinder drives similar to the performance records that have become routine on Pull-Type applications.

GOLDEN JUBILEE

Dayton Rubber

50 YEARS OF PROGRESS

First in Agricultural V-Belts

Agricultural Sales Engineers in Chicago, Moline, New York, San Francisco, Atlanta and St. Louis

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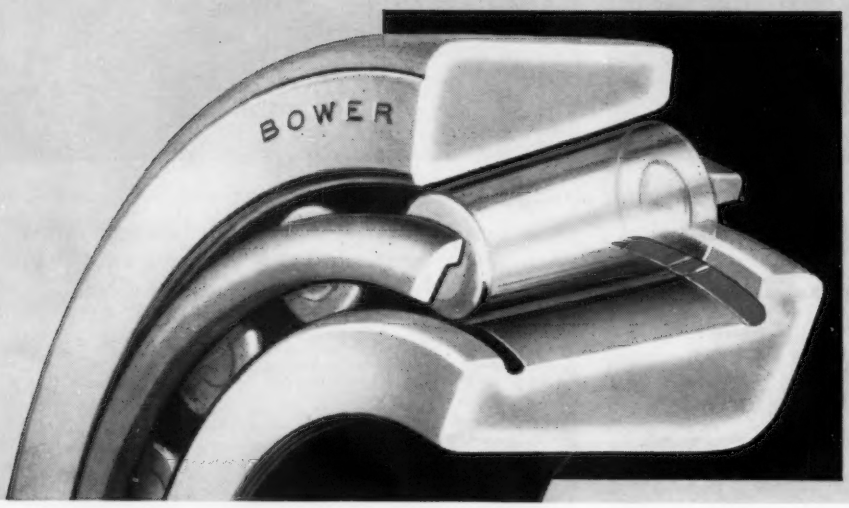
Bower spher-o-honed design provides better bearing lubrication



LARGE OIL GROOVE GIVES POSITIVE LUBRICATION TO ROLLER HEADS

The large oil groove built into Bower Spher-O-Honed bearings is just *one* of several important Bower design features which reduce maintenance and increase efficiency. Combine it with generated spherical roll-heads and a higher flange surface, and smooth, precision-honed races, and you have the basic elements of Spher-O-Honed design.

A careful look at the illustration above will show you other important Bower features, too. Note particularly that the roller heads contact the flange over a wide two-zone area—thus reducing wear and minimizing resultant "end play."

Built of the highest quality materials and workmanship, Bower bearings are available in a complete range of sizes and types to meet your present requirements. Call in a Bower engineer now!

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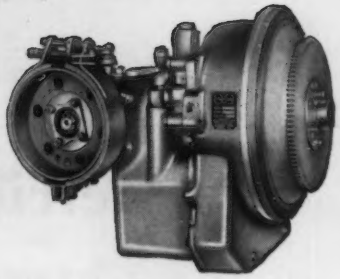
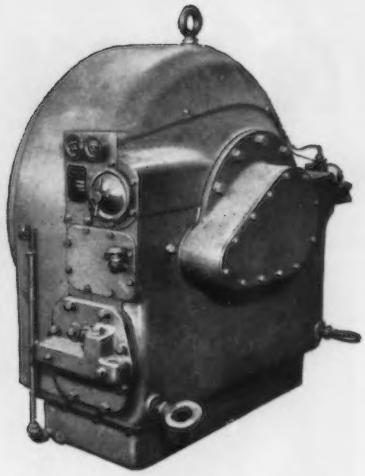
BOWER

ROLLER BEARINGS

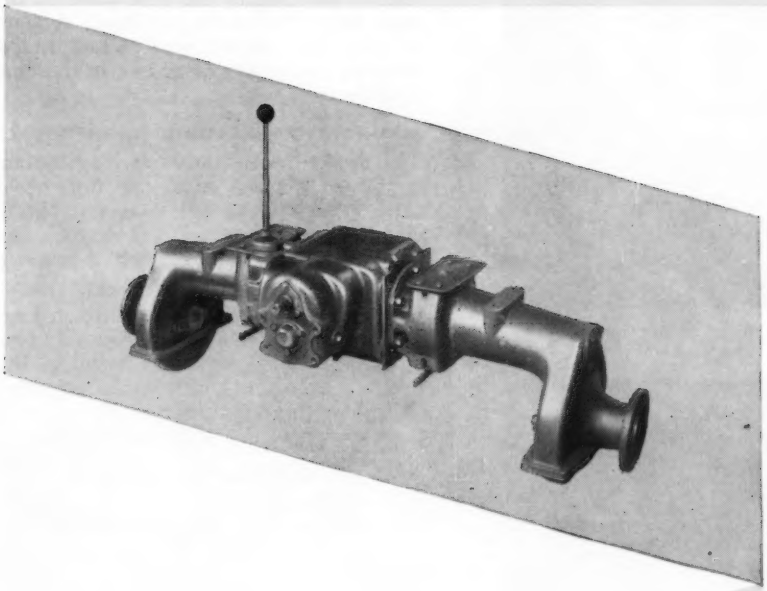
A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS

How to Be Right from the Start





Clark-Torcon Converter Unit



There's nothing like experience—hard-won, hard-headed experience—to determine what *will* work. Which is an excellent reason why leading machinery manufacturers come to Clark for engineering cooperation in developing new machines and redesigning old ones. Instead of employing the old trial-and-error method, with its all too frequent excessive penalties, these manufacturers elected to *be right from the start.* It's their hard-held belief that it's good business to do business with Clark Equipment.

Send for attractive pocket-size booklet "Products of Clark".

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CLARK EQUIPMENT

R B&W FASTENER BRIEFS

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Technical-ities

By John S. Davey

The Proper Loading of Bolts

The pre-load, or residual tension, in a tightened bolt means more to assembly strength than the actual strength of the bolt itself.

In a joint, a bolt torqued to its proper load level resists a maximum amount of external load without loosening. Designers can take advantage of this fact and assure better results, and at the same time, cut costs.

For example: One designer calculated that truck frames needed high strength bolts at least ½" in diameter. So he used ⅝". But on the assembly line, these were being torqued to 100 ft.-lbs. whereas they needed at least 200 ft.-lbs. for proper residual tension. The ½" bolt at 100 ft.-lbs. would actually have given the stronger assembly and at less cost.

In another case, the bucket on earth moving equipment was always coming loose. The design engineer kept increasing the size of the bolt up to 1¼", but to no avail. The impact wrench used was supplying far too little torque for this size. We suggested a return to the original ¾" bolt used, set up to 350 ft.-lbs. torque. It solved the problem.

In short, the more you stress a bolt within its elastic limit, the greater its ability to stay tight and make a strong assembly.

Symmetrical flow lines assure strong bolt heads

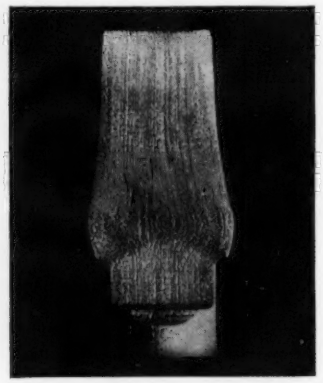


Photo of perfect cold worked blank after first upset.

Effect of improper forming is a poor head like this.

IN THE manufacture of bolts and cap screws, the first upset of metal is a vital one. It determines the flow lines in the bulb which will form the head. A symmetrical flow assures no laps and, therefore, no weak spots or cracks in the final upset of the head.

MACHINE OPERATOR'S SKILL VITAL

The upper photo shows a longitudinal section of a blank after the first upset and on its way to becoming an RB&W standard bolt. Note the even distribution of flow lines. This bulb will become a perfect head.

The lower photo shows what can happen with poor tools, inexperienced operators or without precision setup of the cold headers. Note how pronounced is the unbalanced flow pattern which resulted from a bulb with just a minute defect.

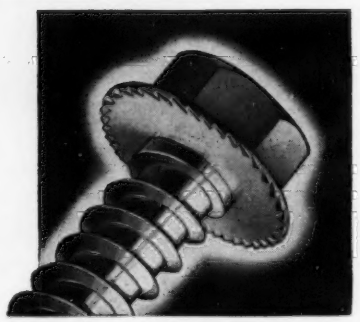
DEPENDABLE FASTENERS

Cap screws and bolts also get a bright smooth finish from the right kind of cold forming. But above all, they offer the designer low cost fasteners with sound internal structure. Standard RB&W fasteners can be loaded to their proper level —become a strong point in any assembly.

For help on your fastener problem, contact Russell, Burdsall & Ward Bolt and Nut Company. Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

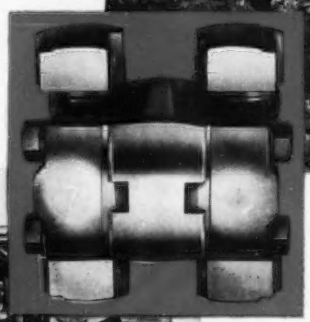
The Only Screw That Stays Tight

The continual heating and cooling caused loosening of handle screws on the flat irons of one manufacturer. Every type tried failed to stay tight until RB&W's unique Spin-Lock tapping screws were used. This solved the problem. Their hardened teeth lock into the surface, require more torque to loosen than to tighten. One piece fasteners, they speed assembly time.

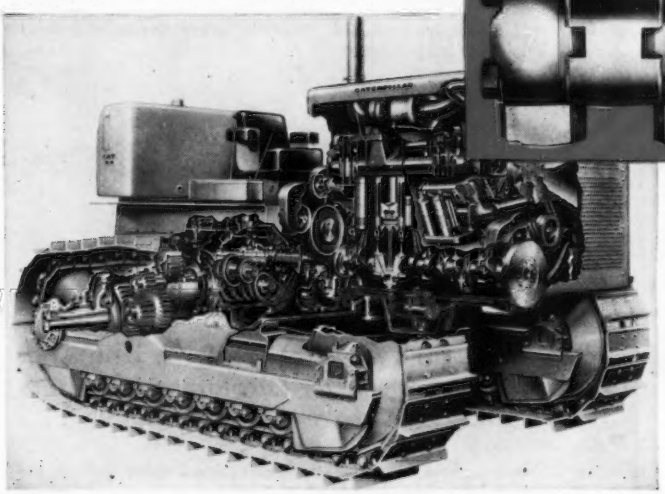


BEHEMOTH

All of the world's "biggest" tractors depend on MECHANICS Roller Bearing UNIVERSAL JOINTS to compensate for heavy-duty shocks and strains — severe enough to twist tractor frames. MECHANICS key-drive strength, flexibility and balance are unanimously specified by the largest tractor manufacturers to keep huge capacity machines operating long hours, day-after-day. They



The Cat D9 Tractor, shown below, sixth machine in Caterpillar's crawler line, is a 230-drawbar horsepower turbocharged tractor resulting from 10 years of big tractor research and development.



Thoroughly field tested during 1954, when Caterpillar put ten D9Xs on various jobs from coast to coast. This 56,000-pound machine has many earthmoving, construction, logging and pipe laying applications.

can't afford to permit large tractors and equipment to be kept idle by needless down-time. Let MECHANICS engineers help build reliability into your (200 to 50,000 foot pounds torque capacity) machines.

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Borg-Warner • 2046 Harrison Ave., Rockford, Ill.

MECHANICS

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UNIVERSAL JOINTS

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International Harvester Company Farmall Cub Tractor does a discing job—one of its many round-the-clock tasks.

To make a tractor engine run better longer ...*specify* PUROLATOR

On farms throughout the country, a tractor is an economic necessity.

From dawn to dusk—often on through the night—today's "steel horses" keep hard at it—often in fields clouded with dust.

A breakdown, a few hours' delay—at planting or harvesting time—can seriously affect the farmer's entire year's profits.

Tractor makers know this! That is why they give top attention to lubrication systems; why efficient oil filtration is a "must" in today's tractor engine design.

PUROLATOR
WORLD'S FINEST OIL FILTER

5 reasons why more major tractor manufacturers specify Purolator-built filters and refills than any other make

1. Purolator's famous "accordion-pleated" Micronic filter element has *up to ten times more filtering area than ordinary types.*

2. Electron micro-photographs prove that Purolator Micronic filters stop harmful particles microscopically small from reaching delicate engine parts.

3. The pleated design of the Purolator Micronic filter element provides *many times more dirt storage space than old-style filters.*

4. With its larger filtering area, the Purolator Micronic filter element introduces a remarkably small pressure drop into the lubricating system . . . *permitting pumps of practical size and simple type.*

5. With Purolator Micronic Filtration, the tractor operator keeps all the oil quality he pays for. *The Micronic filter element will not strip additives . . . an important advantage with H.D. and heat-resistant oils.*

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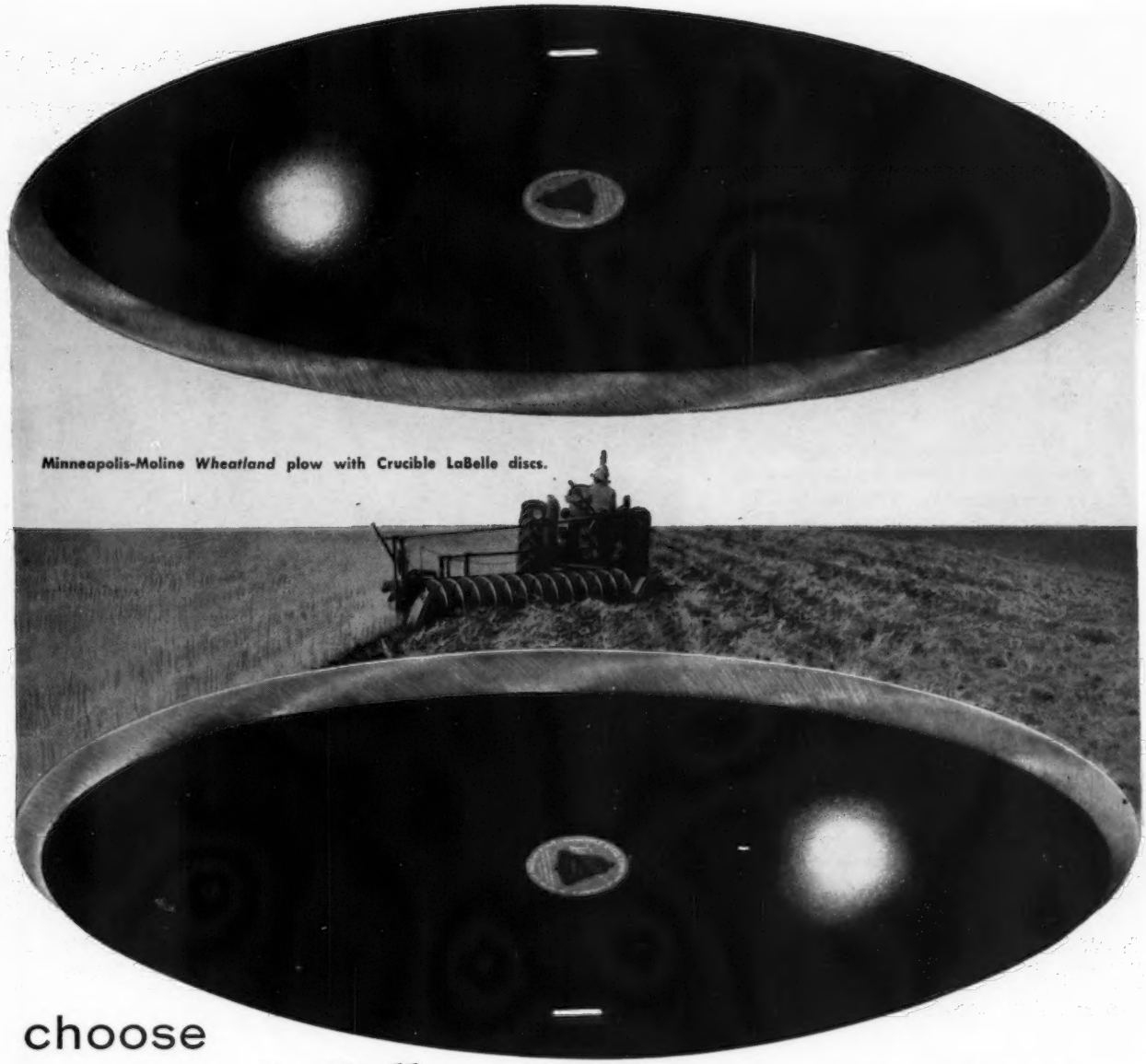

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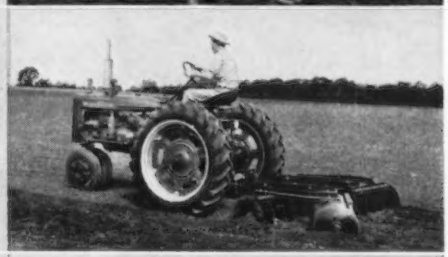

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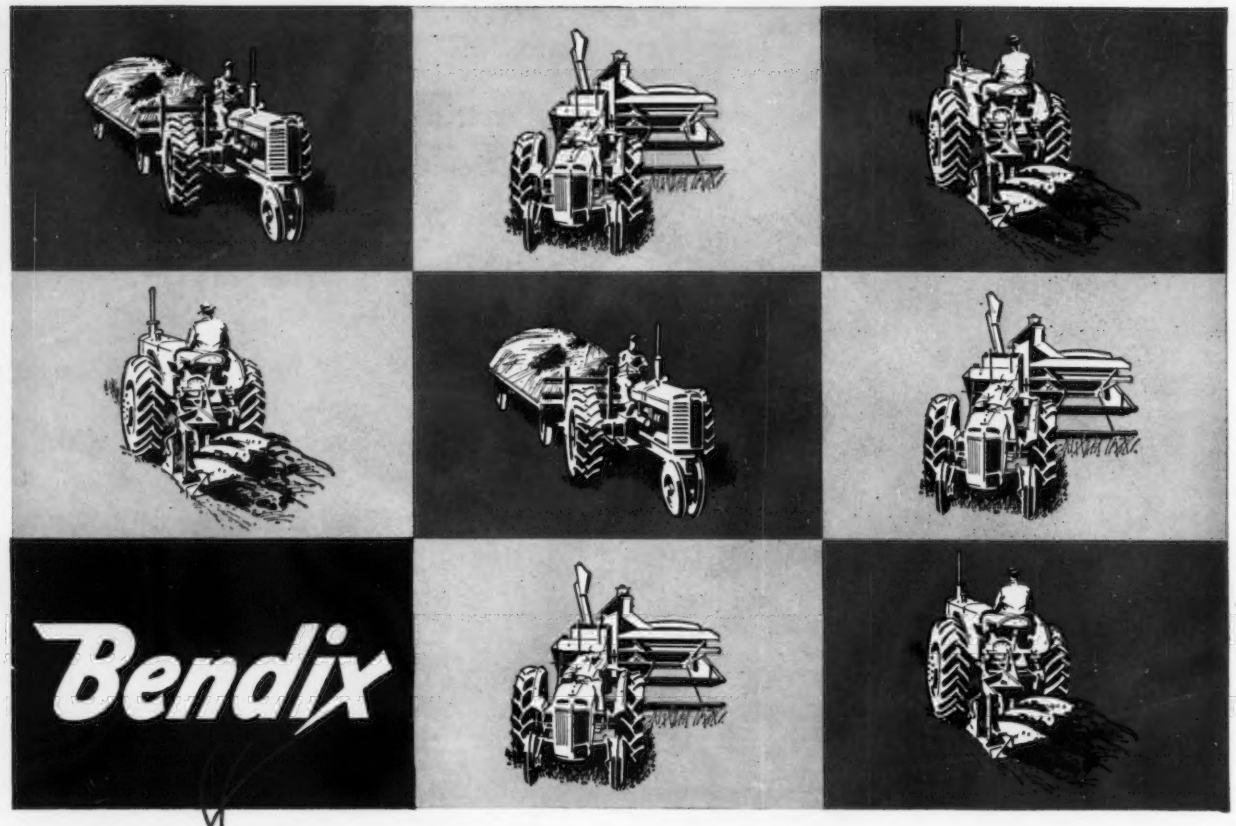

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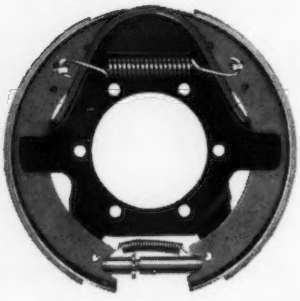

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SHORTAGE of water in many areas and high cost of irrigation have spurred the development of contour farming. The objective is to keep ditches and ridges on a level plane to prevent water run-off. E. L. Wetzig of Carrizo Springs, Texas, invented the contour tractor level shown here. The bar on the top always remains in a horizontal position, thus enabling the operator to chart his course through the field accordingly. Mr. Wetzig, like keen farmers and ranchers the country over, finds that *it pays to farm with Texaco products.*

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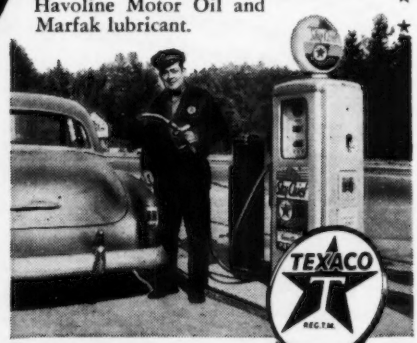

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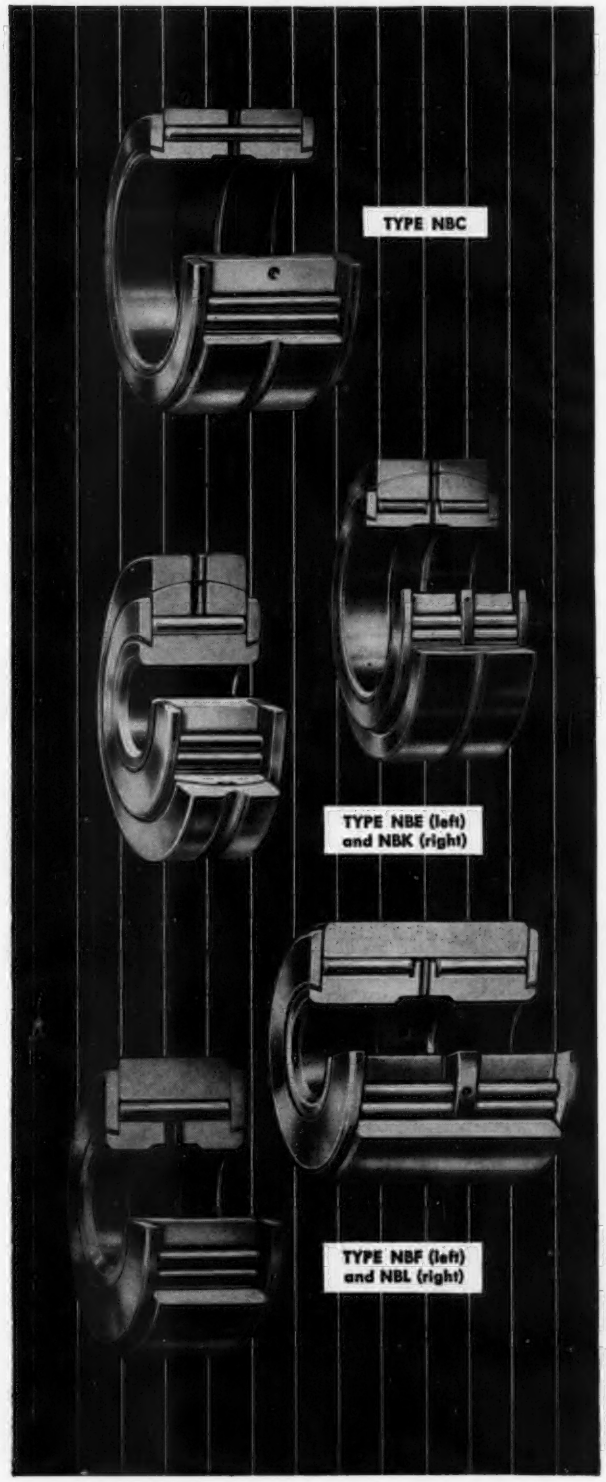

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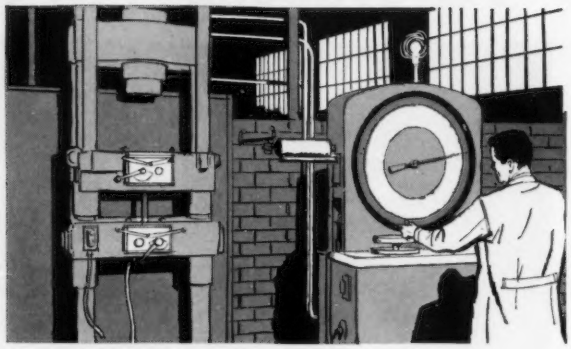

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AGRICULTURAL ENGINEERING

VOL. 36 AUGUST, 1955 NO. 8

Soil Structure and Consistency in Tillage Implement Design

M. L. Nichols and C. A. Reaves
Fellow ASAE Assoc. Member ASAE

THERE is a great demand for specific factual information dealing with the packing of soil and the formation of dense layers and plow soles by implements and traffic and the alleviation of such conditions by subsoiling or subsurface tillage. In areas these dense layers have been reported to seriously damage crop production by materially affecting water, air, and temperature conditions in the soil and by limiting root development.

To assist in meeting these conditions the USDA Tillage Machinery Laboratory, Auburn, Ala., has inaugurated a series of projects dealing with the basic relationship of the elements of design of tillage implements to soil in various physical conditions. Particular attention is given to soil structure and consistency. The major difficulty in evaluating the effects of tillage is in making a true appraisal of actual soil conditions beneath the surface before and after the operation. This article reports the chief items of consideration in studies of tillage machinery now under way and gives a list of methods that has been found useful in the appraisal of soil factors.

Numerous subsoiling experiments have been conducted in the field on soils that have a wide range of physical conditions without appraisal of the effect of these conditions. In many cases, it has been impossible to evaluate results from the data with any degree of precision and repeated tests frequently produced contradictory results. The reason for such a wide variety of results can be explained in many cases by the failure to determine and evaluate *(a)* the soil physical conditions at the time tillage forces were applied, *(b)* the effects produced by these forces, and *(c)* the durability of these effects under given climate and traffic. The soil, to a depth of 18 to 24 in or more in extreme cases, may be affected in a way beneficial or detrimental to plants by the passage of the tractor and the tillage implement. The depth and amount of effect depend upon the nature of the soil material, its structure and consistency. These factors may or may not be evident from the surface, and changes in physical conditions sufficient to materially modify the root environment may be produced without being noticed.

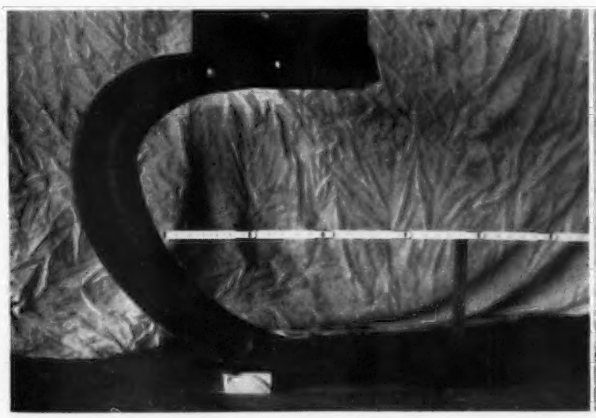
Optimum results with a particular tillage machine can be obtained only when the soil is in a specific physical condition. Improved and simplified methods of evaluating soil condition can serve as guides to selection and design of tillage tools

Baver (1)*defines soil structure as the arrangement of soil particles, meaning by the term particle not only the individual mechanical elements but also the structural elements formed by aggregation of primary particles into small cubelike, prismlike, or platelike arrangements. These elements may be compounded into large or small clods which may be the predominant structural characteristic of the soil.

Paper prepared expressly for AGRICULTURAL ENGINEERING.

The authors—M. L. NICHOLS and C. A. REAVES—are, respectively, head, tillage machinery laboratory section, and agricultural engineer, agricultural engineering research branch (ARS), U.S. Department of Agriculture, Auburn, Ala.

*Numbers in parentheses refer to the appended references.



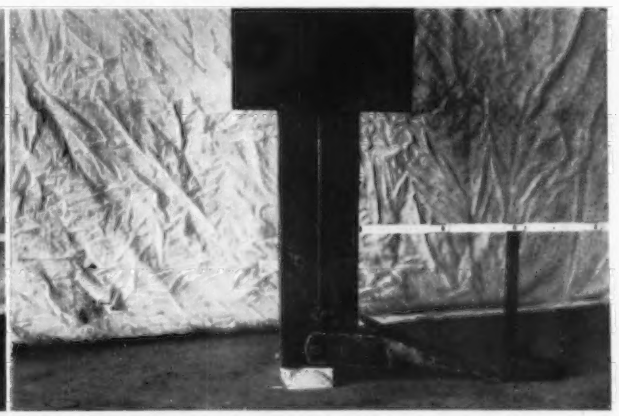


Fig. 1 *(Left)* A subsoiler that tends to lift the soil at a gentle angle and breaks the soil loose with little or no pressure from the standard • Fig. 2 *(Right)* A subsoiler with the standard so close to the chisel point that the standard itself exerts considerable pressure before the soil is broken loose.

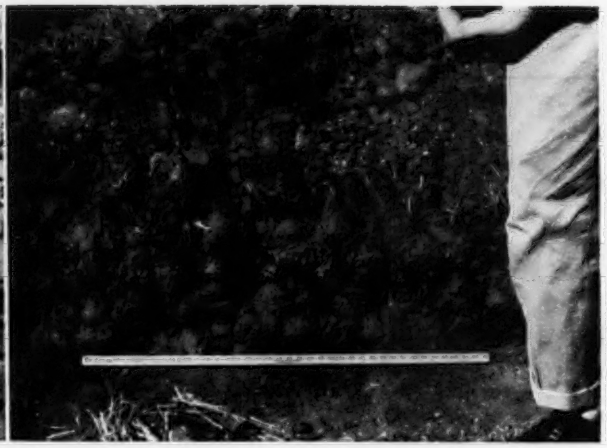


Fig. 3 *(Left)* Hiwassee sandy loam plot after tests of 55-in sweep without coulter on left and with coulter on right. Depth of tillage is 12 in • Fig. 4 *(Right)* Cavities produced in Decatur silt loam by a subsoiler. These cavities had been persistent for at least three years

The structure may be dense and impervious or loose and pervious and may contain a wide variety of plant and rock material. Obviously these conditions are important in determining if the passage of a tillage implement will be beneficial, have little or no effect, or be detrimental as far as conditions that affect plant growth are concerned.

The modification of structure by an implement also depends in large part upon the consistency of the soil at the time of application. J. C. Russel (2) defines consistency as a "term to designate the manifestations of physical forces of cohesion and adhesion acting within the soil at various moisture contents." With any given structure the soil properties of resistance to compression and shear, as well as its friability, plasticity, and stickiness, depend upon moisture content.

Since the same operation may be beneficial or detrimental, depending upon the present structure and consistency, it is necessary to evaluate these factors both qualitatively and quantitatively. To understand the effects of tillage we must know:

- The kind, magnitude, and direction of force applied by a tillage or tractive implement (determined by analysis of design and dynamometer tests)
- The soil structure and consistency at the time of the implement operation (determined by field and laboratory measurements of bulk density, pore sizes, permeability to air, water, aggregates, etc.)
- The modification of soil structure produced by tillage or tractive forces at existing soil structure and consistency (determined by evaluation of changes produced in conditions listed in the preceding paragraph).
- The subsequent effects of climatic, biologic, and traffic forces acting on the soil (determined by same measurements at later dates or by evaluation of structural stability.

The analysis of force applications by various designs of tillage implements in itself frequently presents a complicated problem, since the curvature of the surface-applying force may be complex and may approach the soil at various angles. Generally, the simplest approach is to analyze the reaction of soil to an implement by observation of shear planes and rotations of the soil in a moist sand where light

Fig. 5 Cavities produced by cross-tilling Decatur silt loam. These cavities had been persistent for at least three years

stresses produce visible strains. Models that have a suitable range of variation can be constructed and tested to evaluate particular features of design. Dynamometer readings are, of course, necessary to determine the amount of force required for different full-scale operations on different soils.

As an illustration of what is meant by an analysis of design, Figs. 1 and 2 show two radically different designs of subsoilers built for the same tractor. The implement in Fig. 1 tends to lift the soil at a gentle angle and then breaks the soil loose with little or no pressure from the standard that holds the subsoiler or chisel. The lifting action tends to produce a mixing of the soil. In Fig. 2 the standard is so close to the chisel point that the standard itself exerts considerable pressure before the soil is broken loose. This produces quite a different soil reaction and results in an increase in draft over that of the implement shown in Fig. 1. In Houston clay, for example, the average drawbar pull of the straight-shank chisel was 2,040 lb, while the implement in Fig. 1 had a pull of 1,660 lb. Fig. 3 shows the effect of pressure of a standard that carried a 55-in sweep in Hiwassee sandy loam soil. The pressure of the standard on the "through" at the right was relieved by a passage opened with a disk coulter so that the sweep exerted a lifting pres-

TABLE 1. MOISTURE, BULK DENSITY, AND BEARING POWER RELATIONSHIPS FOR FRAGMENTED SAMPLES OF DECATUR SILT LOAM

Moisture	Bulk densities (lb per ft³) at equilibrium under various pressures Pressures (lbs per in²)								
%	2.5	5	10	15	20	30	40	50	60
9.25	67.7	70.5	74.3	76.6	79.0	82.8	85.4	87.4	89.7
11.20	68.1	70.5	74.6	78.6	79.5	83.3	86.2	89.0	91.9
13.66	66.9	70.8	76.9	80.9	83.3	88.0	92.1	95.0	98.2
16.52	68.8	75.9	84.0	89.7	92.8	98.0	103.0	105.8	107.5
17.90	70.3	79.3	89.9	97.6	100.6	105.6	107.8	108.3	109.4

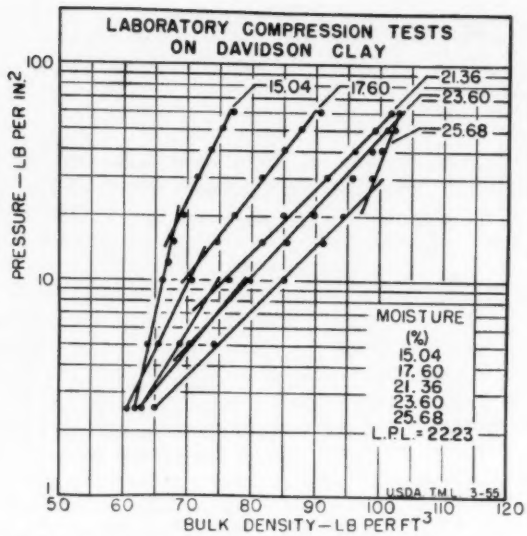


Fig. 6 Graph shows relationship of moisture, bulk density, and bearing power with fragmented samples of Davidson clay

sure on the soil producing little forward motion. The passage shown on the left evidences the pressure of the standard since the soil slid forward on each shear plane as it was developed.

Determination of the structure of a soil at the time of an operation requires careful examination. Structures produced by former tillage or traffic may persist for many years. Fig. 4 shows old chisel marks that persisted for several years in the plot of Decatur silt loam. Such grooves, of course, had been affecting draft tests so that the plot was cross-tilled by a special apparatus designed for that purpose. Fig. 5 shows that the paths of the cross-tiller chisels also persisted after three years. During this period the plot had been used for tests of subsoilers and the top 6 in rotary-tilled. The cavities were, in most cases, continuous across the plot with a compacted layer of soil between each of them.

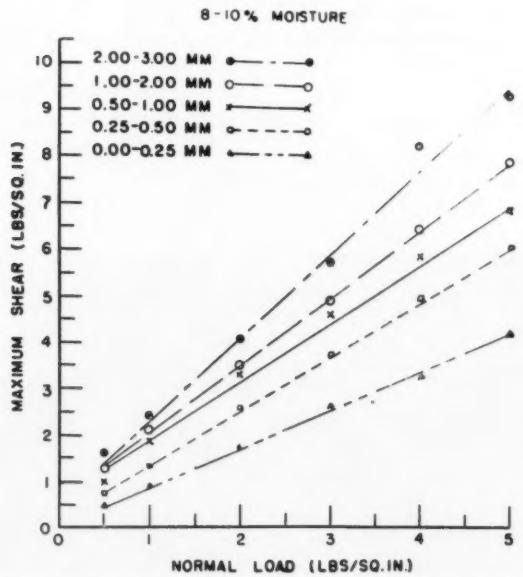


Fig. 7 The effect of aggregate size on shear in Hurricane clay at different normal loads

An examination of the soil in the Decatur plot indicated that there were wide variations in bulk density and moisture content throughout the soil mass. A steel box was constructed which could be pressed into the soil and withdrawn with a practically undisturbed sample. Since the study of structural variation within the plots of the Tillage Machinery Laboratory is incomplete, a typical example of the findings in only one sample of Decatur silt loam will be given here. This sample was 18 in long, 12 in wide, extended from 0 to 16 in deep, and weighed 222 lb. The average dry bulk density of the soil was approximately 93.6 lb per cu ft. Of this total weight, 41 lb were in hard dry lumps with a dry bulk density of 112 lb per cu ft and a moisture content of 15.6 percent; 29 lb were in softer lumps with an average dry bulk density of 108 lb per cu ft but which had a moisture content of 18.5 percent. Since the lower plastic limit is 18.04 percent, this portion of the soil was in a plastic condition. The remaining 152 lb of the sample crumbled into fine material, largely small aggregates, with a calculated bulk density before crumbling of 88 lb per cu ft and an average moisture content of 15.1 percent. The fine material included the surface 6 in which had dried out after rotary-tilling. The lower 10 in contained lumps of the two distinct densities given above which were presumed to have been formed by previous tillage operations, some fine material and the cavities shown in Fig. 5. Since the loose lumps were found to wet more rapidly than the hard dry ones and since the two were intermixed with some fine material and large open or loosely filled channels, it is obvious that the same tillage operation could produce entirely different results when performed at different moistures. The amount of water to produce a material change in this case would depend upon the quantity and condition of the medium lumps which react first with water and may become critically plastic while the hard lumps are relatively dry.

Table 1 shows moisture, bulk density, and bearing power relationships for fragmented samples of Decatur silt loam. Bearing power is defined, in this case, as the pressure which a soil with a given bulk density and moisture content will support without a decrease in volume due to compression. These relationships should provide a fairly sound basis for predicting soil compaction under various pressures applied by tillage implements.

Fig. 6 shows similar results which were secured from confined compression tests of a Davidson clay soil. It should be noted that there are definite breaks in the curves as the structure of the lower part of the curve depends upon how the soil was placed in the container and the upper part upon moisture films. The curves of 25.68 percent and 23.60 percent moisture are above the lower plastic limit where pressure fills a large portion of voids with water.

The size of aggregates is an important factor in the reaction of a soil to tillage forces. In order to determine the effect of aggregate size on the shearing strength and on the compressibility of soil, sieved separates of fragmented soil were studied. Dry aggregates of Hurricane clay were moistured through the tillable range of this soil by the steam condensation method and shear and compression tests were made. The mineral fraction of this soil contains about 45 percent montmorillonite and 15 percent kaolinite. Approximately 86 percent of the soil particles were smaller than fine sand, that is, less than 0.02 mm. Figs. 7 and 8, typical curves from the

study, give the effects of aggregate size on shear and compression of the Hurricane soil at 8 to 10 percent moisture. In all cases the shear values were related to the aggregate size, the larger the aggregate size the larger the shear strength. In this particular case the shear value of 2 to 3 mm aggregates was over twice that of 0.25 mm aggregates. There was found to be a consistent relationship between bulk density produced by various pressures and aggregate size; the bulk density increased with a decrease in aggregate size.

An important consideration in tillage is the permanency of the results. Some indication of durability of results in the plots has been given in this article. Extensive field experience has shown that serious compaction may occur in the heavier soils if worked at a moisture content above the lower plastic limit. This compaction may persist for a number of years or until the puddled condition is corrected by natural forces such as freezing and thawing or repeated wetting and drying. The properties that produce persistence of effect are considered in beneficial practices, such as subsoiling, where the costs frequently are so high that the conditions brought about by deep loosening must continue over several crop sequences to be practical. Fig. 9 shows the effect of subsoiling on Lloyd clay pasture. The subsoiling had been performed more than two years when the soil was examined. Each furrow was easily found and observation showed that roots of the pasture plants had penetrated to the depth of the subsoiling. It is believed that plants which had penetrated the soil as a result of subsoiling assisted the preservation of desirable structure but additional evidence is needed.

Yoder's report (3) of the significance of soil structure in relation to the tilth problem presents an excellent analysis of the factors involved and also valuable data on the persistence or durability of clod structures that may be produced by tillage. By dry sieving he separated a wide range of clod sizes in Cecil clay soil in which he raised cotton. The range of particle sizes were from under 1/16 to 4 in. Some plots contained only one clod size and others contained combinations of sizes. He characterized the structures with a "modulus of pulverization" in which the amount of soil in clods and the size of clods increased as the modulus increased. Table 2, derived from Yoder's report, shows the persistence of the clod structures through the year. An examination of the same soil by Kummer (4) some eight years later showed that the clod structures persisted with a similar pulverization modulus.

TABLE 2. PERSISTENCE OF CLOD STRUCTURE IN CECIL CLAY (ref. 3)

	Pulverization Modulus													
Plot No.	2	3	4	13	5	14	8	15	9	16	10	17	11	18
At planting time	0.00	0.66	1.43	2.00	2.29	3.00	3.18	4.00	4.06	5.00	5.03	6.00	6.03	7.00
At maturity	0.04	0.54	1.20	1.65	1.92	2.53	2.53	2.98	3.10	3.86	3.82	4.09	5.09	4.77

From these studies and observations, the conclusion has been drawn that in order to obtain reliable, consistent, and understandable results with different implements and soils, it is necessary to precede and to supplement all tillage studies or tests of implements with physical measurements and studies of the soil material. There is real need for the agricultural engineer to develop and organize the expensive and uncertain art of tillage into an organized body of knowledge which can be classified as a science. Known methods of evaluating soil physical conditions should be applied directly to all tillage studies, but we must develop better methods of directly relating soil reactions to various features of design of implements. Attempts are being made to improve and simplify existing methods and to develop new techniques for an understanding of this relationship.

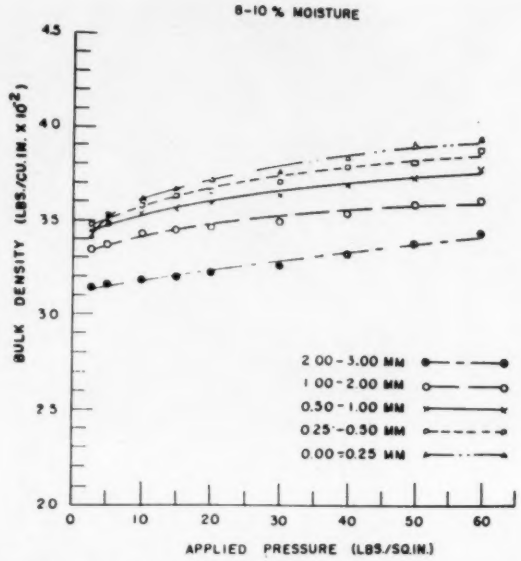


Fig. 8 The effect of aggregate size on compaction in Hurricane clay at different applied pressures

The following measurements have been found to be helpful in understanding soil-implement relationships. It is recognized that the present methods are slow and cumbersome, but it is believed that greatly simplified procedures can be developed which will give reasonably quick means of evaluating soil conditions and which will serve as guides to selection and use of tillage tools. It should be noted that the measurements apply to clean cultivated mineral soils, which may contain considerable quantities of decomposed or largely decomposed organic matter. Other methods must be used to evaluate the effects of sods, rocks, and other materials found in soils.

Methods of evaluating soil structure as related to implement design:

1 Visual and manual examination of soil layers and profiles using spade or digging tools

2 Sieve analysis of surface

(Continued on page 522)

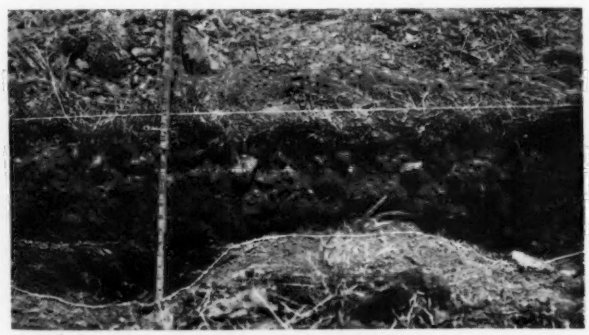


Fig. 9 Results of subsoiling on Lloyd clay. These loose conditions had been persistent for two years

Drawbar Dynamometer Using Strain Gages

A. W. Clyde
Fellow ASAE

THE circuit described by Mr. Jensen (1)* has attractive possibilities for securing average force values. Its simplicity and portability make it very useful. This article describes how it has been applied with minor changes to a two-range dynamometer for general use.

The ring as illustrated by Mr. Jensen has the good feature of being able to withstand a bending moment. Its drawback is that it is practically impossible to design it for any certain stress because of the change in cross section at points at attachment. Simple beams shown in Fig. 1 were selected for the dynamometer described below because they can be planned easily for the rather high strains which are desirable when using a strain-gage circuit of relatively low sensitivity.

Design of Beams

It was decided to plan for a capacity of 5000 lb with a strain of 0.0015 in per in in the outer fibers at midspan where the gages are located. A span of 8 in center-to-center of end holes was selected with a ⅝-in hole at the center. One-inch thick 24 S-T aluminum alloy was available and was chosen because of its easy working qualities. Its modulus of elasticity is about 10,300,000 psi, hence a strain of 0.0015 in per in is secured with a stress of practically 15,500 psi. This is about one-third of the yield strength of this alloy. A load of 5000 lb midway between supports 8 in apart gives a bending moment of 10,000 lb-in. The calculation for depth of beam needed is given in Fig. 2. Properly heat-treated 1045 steel at a stress of nearly 45,000 psi could have been used. If it were ½ in thick, the depth would need to be slightly less than 1.68 in.

The author—A. W. CLYDE—is professor of agricultural engineering, Pennsylvania State University.

Paper prepared expressly for AGRICULTURAL ENGINEERING. Authorized for publication on June 14, 1955, as paper No. 1987 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

*Experimental Stress Analysis, James K. Jensen. AGRICULTURAL ENGINEERING vol. 35, 626-29 and 634, September 1954.

Acknowledgment: The assistance of graduate students, J. J. Ahne and W. H. Park, also of F. T. Hall, Jr., of the electrical engineering department, is acknowledged.

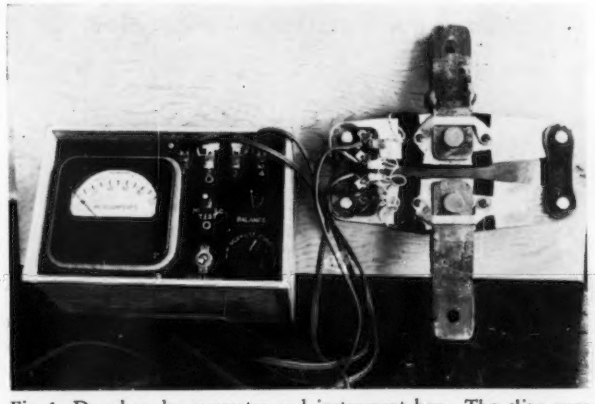


Fig. 1 Drawbar dynamometer and instrument box. The clips over the clevises are to restrict side swinging of the clevises and damage to gage wires. For the same reason, one of the end straps has stops to prevent the two beams from getting close together

A previously described circuit for strain-gage measurements has been applied to a two-range drawbar dynamometer

Gages

Mr. Jensen mentioned the need for a high gage factor and high resistance with this circuit. Long life also dictates a bakelite bonded gage in preference to the common cemented type. For these reasons the CB7 gage was chosen, it being a bakelite bonded gage with 500 ohms resistance and a factor of practically 3.4.

Circuit

The modifications of the circuit were the use of a better microammeter (470 ohms resistance instead of 1000 ohms) and two calibrating resistances to give two ranges of measurement. (See circuit diagram Fig. 3.) In preparation for use the meter is first made to read zero with the balancing potentiometer. If a large pull is expected, one of the calibrating resistances is shunted across R_1 (the other gages being unstrained). The battery rheostat is then adjusted to give a meter reading of 100 and the instrument is ready for use. For a pull of less than half capacity, the procedure is the same except that twice as much resistance is shunted across R_1.

The value of the calibrating shunt can be selected by using the fact that at a strain of 0.0015 in per in, the resistance of each gage will change 2.55 ohms. If the small

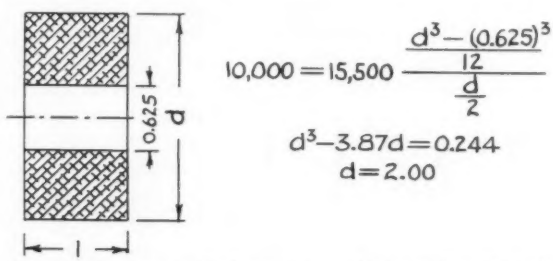


Fig. 2 Cross section of a beam at its midpoint with method of calculating its size

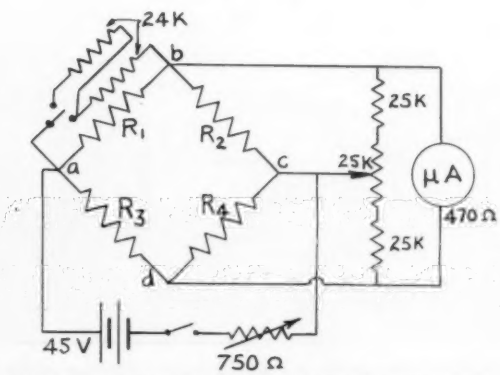


Fig. 3 Diagram of modified circuit used for strain-gage measurements

current in the meter and the balancing network is neglected, it can be determined that 490 ohms in place of R_1 (with the other gages remaining at 500 ohms) will give practically the same voltage drop between *b* and *d*, Fig. 3, as will be secured with all gages fully strained. A resistance of 490 ohms between *a* and *b* can be obtained by putting 24,000 ohms in parallel with R_1. Similarly, 48,000 ohms in parallel with R_1 provide approximately a half-range. Great precision is not needed in calculating these resistances since the instrument is to be calibrated. More than two ranges can, of course, be provided if desired.

A higher strain and stress could doubtless have been used with 24 S-T alloy. A strain of 0.002 corresponds to a stress of less than half the yield strength and should be allowable. If this is done, the calibrating resistances should be reduced from 24,000 ohms to 18,000 ohms and the battery rheostat increased to 1500 ohms. In case 1045 steel is used in the beams, probably a strain of 0.0015 in per in is as high as should be planned for.

It is interesting to note that when the equation on page 626 of Mr. Jensen's article, is applied to this instrument, the battery current in HI range is computed as 38 μa (microamperes). Measurement shows it to be actually 37½ to 38 μa in HI range. In LO range it is 70 μa.

Calibration and Use

Calibration in a testing machine confirmed the design fairly closely. For practical purposes 1 μa equals 51½ and 25¼ lb in HI and LO ranges, respectively. The dampening is enough to permit good visual readings. For example, in pulling a two-bottom plow the meter hand moves slowly enough so that readings can be noted down for averaging in case a motion picture record is not needed.

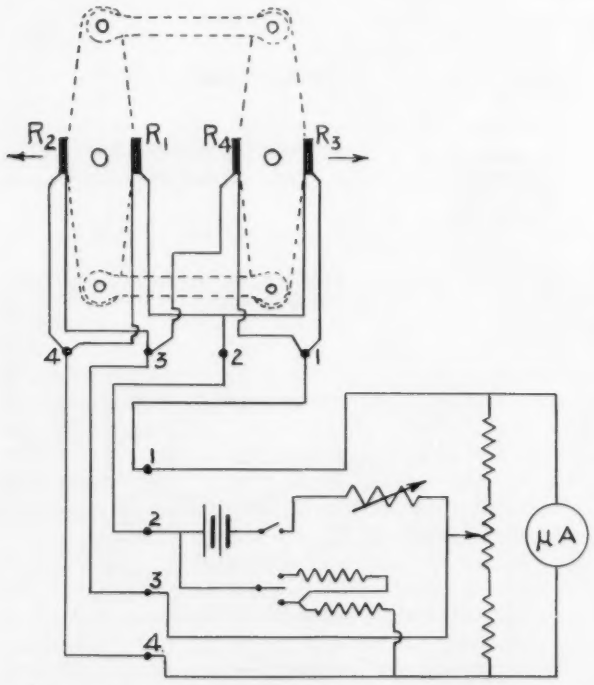


Fig. 4 Wiring diagram to put all electrical equipment except the gages in an instrument box which can be readily disconnected

Two precautions deserve mention. The first of these is that the meter may drift downward slowly in the first few minutes of use. The setting of the battery rheostat should be checked frequently to correct this. The second precaution is to avoid contacting both the battery switch and the HI or LO test switches when the gages are disconnected. Such action completes a circuit through the balancing network and the meter which permits flow through the meter of a considerably larger current than the meter's capacity.

Electrical Parts Needed

4 SR-4 strain gages, type CB7
1 4½-in panel microammeter, 470 ohms
1 potentiometer, 25,000 ohms
2 resistances, ½ w, 25,000 ohms, 5 percent
2 resistances, ½ w, 24,000 ohms, 1 percent
1 rheostat, 25 w, 750 ohms
1 toggle switch, SPST
1 toggle switch, SPDT, momentary contact
1 B battery, 45 v, similar to RCA VSO 13
Binding posts or clips and connecting wire
The cost of this material is approximately $50.00.

Soil Structure in Implement Design

(Continued from page 520)

soil where clodiness appears to be an important element of structure

3 Location of dense layers by penetrometer
4 Determination of bulk density by core samples, air pycnometer, or gamma-ray densitometer
5 Measurement of pore size by tension-table porous plate or pressure membrane
6 Measurement of water-stable aggregates by wet sieving and air-water permeability.

Useful methods of evaluating implement effects due to consistency:

1 Moisture measurements, gravimetric and volumetric
2 Determination of consistency constants
3 Determination of confined compressibility-moisture relationships
4 Determination of arch action-moisture relationship or pressure distribution through the soil
5 Determination of shear-moisture relationships
6 Determination of swelling and shrinkage.

References

1 Baver, L. D. Soil Physics, John Wiley & Sons, New York, p. 126, 2nd edition, 1948.

2 Russel, J. C. Report of Committee on Soil Consistency. Am. Soil Survey Assoc., Bull. 9, pp. 10-12, 1928.

3 Yoder, R. E. The significance of soil structure in relation to the tilth problem. Soil Science Society Proceedings, 1937.

4 Kummer, F. A. Unpublished annual report to the director of Alabama Agricultural Experiment Station, 1945.

A Correction

IN THE article entitled "Sediment Production in Small Watersheds" by Russell Woodburn in AGRICULTURAL ENGINEERING for July, attention is called to an error in the equation at the top of the first column on page 468. The second "*S*" in this equation should read "*C*" instead.

Engineering the Hillside Combine

Homer D. Witzel and Bernard F. Vogelaar

Feats of engineering achievement that rank with the best in the evolution of present-day agricultural machines account for the development and success of the modern self-propelled hillside grain combine

VAST areas in the Pacific Northwest states of Washington, Oregon and Idaho as well as in California, have excellent climatic and soil conditions for growing wheat, barley and dry peas. Most of this land is very hilly and a specialized type of agriculture with specialized hillside harvesting equipment is required.

As the steel plow made possible the tilling of the vast Central States prairie lands in the middle 1800's so the development of hillside combines made possible the conversion of the rolling hills of the western and northwestern states into productive grain lands. In the thirty-year period after the introduction of the hillside combine (1890 to 1920) wheat production increased seven times in Washington alone.

The USDA in its 1954 crop production report lists 233,000 acres of dry peas, 4,254,000 acres of wheat, and 1,576,000 acres of barley harvested in the three states of Washington, Oregon and Idaho. These acreages represent 85 percent—8 percent and 13 percent respectively, of the total acreages harvested in the United States. Most of this acreage is on sloping ground and must be harvested with hillside combines. In addition, a fair percentage of California's wheat and barley acreage (listed at 2,378,000 acres in 1954) must be harvested with hillside combines.

Grades of the harvested areas vary from level to as much as 65 percent, and the soil is, generally speaking, very fine and loose. The field outlines to a great extent are very irregular. Sometimes the outline of a field will meander around the side of a hill much like a line on a topographic map, with the field on one side having a slope that can be tilled and harvested and falling away or tilting up on the other side to steeper slopes. Sizes of fields vary from a few to several thousand acres. The land is cultivated, drilled and harvested on the contour as much as possible for soil conservation, ease of movement of tractor and harvesting equipment, and to minimize the fore-and-aft leveling problem.

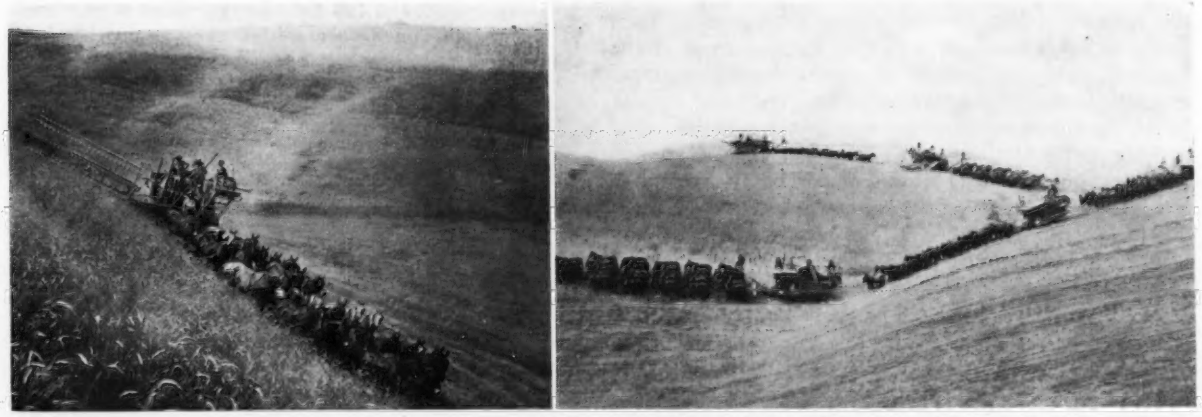
Paper prepared expressly for AGRICULTURAL ENGINEERING.

The authors—HOMER D. WITZEL and BERNARD F. VOGELAAR—are project engineers at the John Deere Harvester Works.

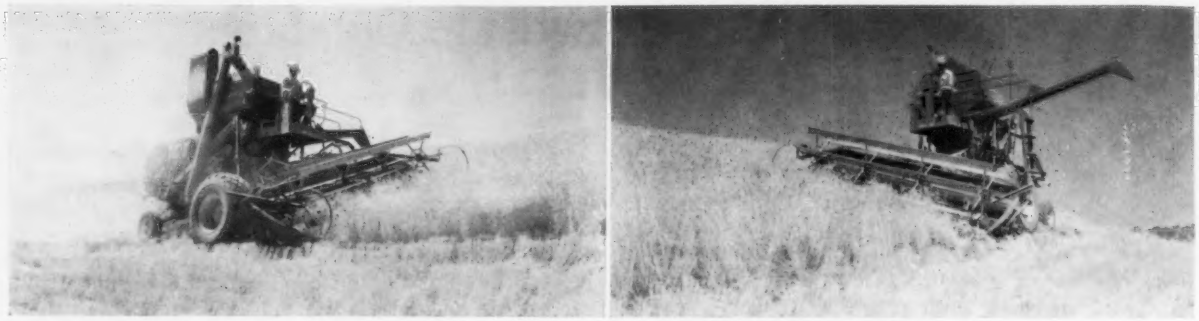
The first hillside combines were made commercially available in the period from 1890 to 1900 . They were large wooden-framed machines drawn by 30 to 44 horses or mules, had ground-traction-driven separators, and required five men to operate (not including the water boy). Steam tractor power was used extensively to replace horses and mules to pull the large level land combines during the period from 1890 to 1910; however, these were not practical in the hilly grain fields. Thus the next big advance in hillside combine development was the introduction of the internal-combustion engine in 1904 as auxiliary power to operate the threshing mechanism. This development cut down on the number of horses required to operate a combine, and made possible the further conversion of the rolling grass lands to productive wheat fields.

It is of interest to note that Holt Brothers introduced the first self-propelled combine in 1911, and followed with a hillside version in 1912. It is of further interest to note that these combines used variable-speed V belts to drive the header wheel at varying speeds as an aid in steering, along with turning the front wheels. Main traction was provided by a single track under the separator. Holt Brothers also introduced a metal-covered combine in 1913.

These first self-propelled combines did not gain widespread popularity, probably because during the period from 1910 to 1930 the track-type tractor came into being as the primary answer to pulling the large hillside combines. During the period from 1910 to 1949, hillside combine development was marked by general design improvements such as universal adoption of steel frame and body, antifriction bearings, V-belt drives, rubber tires, weight reduction, etc. Another advancement during this period which



(Left) An early "Best" hillside harvester • *(Right)* "Holt" hillside combines like these helped boost Washington wheat production from 6 million bushels in 1890 to 42 million in 1920. (Photos by courtesy of Caterpillar Tractor Co.)



These two views show how a modern self-propelled hillside combine is leveled on opposite slopes. (Photos by courtesy of John Deere Plow Co., Portland (Ore.)

helped to reduce manpower requirements was the adoption of bulk handling of threshed grain, thereby eliminating the sack sewer and sack "jigger". In addition, several ingenious automatic leveling-control devices had been developed, making it possible for a two-man crew to take the place of the original five-man crew.

The relatively recent development and widespread adoption of level-land self-propelled pusher-type combines was watched with a great deal of interest by the hillside area farmers. At least two hillside self-propelled pusher combines went into the field in 1949.

One combine manufacturer put a limited number of hillside self-propelled combines in the field in 1950 and in addition there were several hillside conversions of conventional self-propelled combines made by ingenious inventors in the area.

By 1954 there were several makes of hillside combines available. In addition, 1954 marked the introduction of the first hillside combines with factory-installed automatic leveling controls.

The primary difference between a hillside combine and a conventional combine is that the separator body is kept level regardless of the ground slope. The entire separator body is kept level in the lateral direction. On some combines part of or the entire separator is kept level to some degree, in the longitudinal direction. The need for longitudinal leveling and the advantages gained by it depends somewhat upon the separator design.

Lateral leveling then presents the problem of having the cutterbar and header platform follow the ground slope while the separator remains level. In the pull-type combine this is not a serious problem because the header platform feeds the separator from the side. The inner end of the header platform hinges with the separator while the outer end follows the ground contour with a gage wheel.

In the self-propelled pusher-type combine, the cutterbar and header platform have no gage wheel, being supported from and hinged to the separator body by a lateral pivot axis. To make the self-propelled pusher-type combine into a hillside combine it is necessary to pivot the cutterbar and platform with respect to the separator. A pivot circle or "fifth wheel" large enough to encircle the feeder spout is required. The pivot circle can be placed either to the front or to the rear of the feeder spout. In case of the latter, the angle of discharge of the feeder spout, with respect to the separator body, changes. This results in a problem of feeding the cylinder. Some of the earliest machines had the pivot circle in this position. Most of the combines today have the feeder circle between the header platform and the feeder spout. With this design there is a problem in feeding the grain through the circle; however, a beater just to the rear of the circle seems to solve this problem.

A method is necessary to keep the header platform parallel to the ground slope. This has been done by two basic methods: (1) by a mechanical connection, either linkage or cables, between the header platform and some part of the wheel mechanism and (2) by the displacement of hydraulic fluid between two cylinders. The pump cylinder operates by relative motion between the separator body and wheel mechanism, while the motor cylinder pivots the cutting header platform with respect to the separator body. There needs to be a certain amount of flexibility in either design, because if the connection is made too rigid, part of the weight of the combine will be thrown onto the header platform if a wheel were to drop into a hole.

There are two basic methods used to keep the separator body level. In one method (used in an early experimental machine) the whole under carriage, which includes the power plant, transmission, drive axle, etc., follows the ground slope. The separator body is suspended in a large cradle which is part of the undercarriage structure. The cutting platform is then supported by the undercarriage, eliminating the need for the above described methods to pivot the platform. The front end of the cradle becomes the feeder circle through which the grain must be fed. This method, while simplifying some of the design problems, is not in current use and has two serious disadvantages: (1) the center of gravity is shifted to the low side as the combine goes into a slope, and (2) the wheels are kept perpendicular to the ground and have more tendency to slide downhill than if kept vertical.

In the second method, which is the most popular in current use, the main frame, power plant, transmission, and differential are part of or rigidly connected to the separator body. The drive wheels are supported by swing arms pivoting about an axis, which is part of the separator body. Thus, when this pivot axis remains level along with the separator body, the drivewheels remain vertical.

There are two basic designs used on production combines to transmit the power from the differential to the wheels. The first method is to transmit the power directly from the differential to the wheel through universal joints. Because of the large angle through which the universal joints must work, it is well to have some final-drive reduction in the wheels to keep the torque within reason. The

wheel torque required to pull a 12,000-lb machine with a 3,000-lb grain load up a 40 percent slope with 18-26 tires is an appreciable figure.

The second method is to transmit the power from the differential through a jackshaft located at or near the swing-arm pivot axis, and then through a roller chain to the wheel.

Power to actuate the leveling mechanism has been provided through either mechanical or hydraulic means. Mechanical means has been used for many years on pull-type combines and is still used on at least one self-propelled hillside combine in production today. It consists of a rack and pinion set for each drivewheel. The racks are attached to the drivewheel swing arms and are operated by pinions on a drive shaft. The pinion on one side is located to the front of the rack and the other pinion to the rear of the rack, so that one swing arm will move down while the other moves up. Power is applied to the drive shaft by engaging a clutch.

Hydraulic leveling can be done by using either a double-acting cylinder or two single-acting cylinders. No attempt will be made to discuss various hydraulic circuits, except to say that, if a separate pump is used, the leveling circuit is very simple. If the leveling circuit is integrated with the other hydraulic functions, the circuit is more involved.

When the leveling mechanism is operated by hydraulic cylinders, it becomes necessary to keep the wheel swing arms synchronized, i.e., one swing arm must raise as much as the other lowers, so as not to raise or lower the separator body. This could be done by follow-up linkages operating a hydraulic valve, which would allow only as much oil to drain from the contracting cylinder as is pumped into the lengthening cylinder. This has the disadvantage of having the separator body supported entirely by the hydraulic system.

There are three systems that are being used on production combines to keep the swing arms synchronized: (1) a rack-and-pinion arrangement is used, much the same as described in this paper for mechanical leveling, except that the pinion shaft is not connected to a source of power; (2) mechanical connection between the ends of the two swing arms by the use of cable and pulleys, and (3) a balance beam with the outer ends connected to the swing arms and the center pivoted with the separator body. The pivot axis could be concentric with the feeder circle, if the circle is located to the rear of the feeder spout. The feeder circle half that is connected to the feeder spout then becomes part of the balance beam.

One of the more recent developments of hillside combines, on both pull and self-propelled types, is automatic leveling. On the pull-type combine lateral automatic leveling was never a standard feature, but several special conversion attachments have been made available. Because of the increased demand for automatic leveling, this feature is becoming essential for the self-propelled combine.

There are many interesting problems connected with the design of automatic-leveling controls.

A combine is subject to shock and inertia forces as it travels over rough terrain. It is necessary to dampen these inertia forces from the sensing device. Closely related to the dampening problem is the need to provide a time delay in the sensing device, so that the combine will not level for every small hole.

This time delay gives the automatic leveler a few seconds' handicap over the manual control, because with manual controls the operator quite often anticipates a need for leveling. This time loss requires a combine with automatic controls to level quickly.

There is considerable difference of opinion as to the required speed of the leveling device. This is substantiated by the wide range of speeds used on combines today. A fast leveler, for example, levels from a tilt of 40 percent in 5 sec, while a slow leveler levels in 15 sec. There are three factors that determine optimum speed: (1) type of ground contour, (2) type and speed of combine, and (3) type of controls. The steeper hills with rapid changes of slope require a faster leveler. The self-propelled combine, which in general operates at a higher ground speed than the pull type, also requires faster action. On combines equipped with automatic controls it is necessary for still faster action, as aforementioned. In general, the self-propelled combines with automatic controls do have faster levelers.

The automatic controls must be designed to operate under two extreme ground contour conditions. There are the slow-rolling hills and the steep hills with fast slope changes. It is necessary to design the controls so that there is either a minimum of adjustments or no adjustments necessary for these extreme conditions.

One of the most difficult problems to overcome is to keep the combine from overleveling which results in a hunting condition. The faster the leveling action, the more difficult this problem becomes. If dampening and time-delay features, controlling the sensing device from the neutral position to an operating position, are also effective from the operating position to the neutral position, the combine will overlevel.

The sensing device for automatic control in use today can be classified under two basic groups: (1) those that have the force of gravity acting on a solid mass (a simple pendulum) and (2) those that have the force of gravity acting on liquid.

The pendulum is used to control hydraulic valves directly and it is also used to control sensitive electric switches which energize hydraulic-valve solenoids.

Those controls that depend on the force of gravity acting on a liquid, can be classified in two subgroups: (1) those that use an electric conductor as the liquid, such as a mercury switch, and (2) those that use the force of gravity to create hydrostatic pressure in an enclosed chamber. Hydrostatic pressure is created by a liquid head between the enclosed chamber and a reservoir mounted on the opposite side of the combine. A sensitive pressure switch is then made to operate as the hydrostatic pressure (or liquid head) changes, due to the combine tilting from the level position.

The steepness of the slopes on which these machines operate is so great that any discussion of hillside combine development would not be complete without stressing the need for safety features.

Wide wheel tread with the center of gravity (with filled or empty grain tank) located so as to fall well within the wheelbase at extreme—out-of-level—conditions is required because of the dynamic and inertia forces which are present in field operation.

Effective individual wheel brakes are a must. There are times when steering wheels are ineffective, such as in loose

(Continued on page 528)

Sprinkler Evaporation Losses

K. R. Frost and H. C. Schwalen
Member ASAE Member ASAE

Engineers prepare nomograph for estimating spray losses based on temperature, wind movement, operating pressure, humidity, nozzle diameter and breaking of spray

A STUDY of spray losses in sprinkler irrigation was undertaken to determine the percent of water reaching the ground or vegetative surfaces during application. It was also desirable to study the factors influencing the losses in order that application efficiencies might be improved under Arizona conditions. Results of previous work on the determination of evaporation losses from sprinkler spray indicate that application efficiencies would be extremely low at high temperatures and low humidities. If these results are applied to Arizona conditions and no practical means is found to improve the efficiency of application, it is evident that the sprinkler method of irrigation cannot be generally recommended for this state.

A test plot was set up for collecting the discharge from sprinklers by arranging quart cans on the ground at 6-ft spacings in which the catch in each can is representative of the average depth of application on a 36-sq-ft area. A depth of 1in of water in each can was equal to a volume of 197 cc and over the 36-sq-ft area it represents is equivalent to 3 cu ft of water. The total volume of water reaching the ground surface in cubic feet is equal to the total measured catch in all the gage cans in cubic centimeters divided by 197 and multiplied by 3, or

$$\text{Volume (cu ft)} = \frac{\text{Total catch (cc)}}{197} \times 3$$

The discharge from the sprinkler nozzles was measured through a calibrated meter reading in cubic feet. The loss from the spray in the air is the difference between the metered discharge and the computed amount of water reaching the ground surface, corrected for the evaporation losses which occur after the water reaches the gage cans. Nozzle pressures were measured with a pressure gage attached to the lateral at the base of the riser. Wind velocity was obtained with a Biram anemometer equipped with a directional vane at an elevation of 6 ft above the ground surface. Wet and dry bulb temperature readings were taken four or five times during each test run, at an elevation of 4 ft above the ground surface and outside the sprinkler test area.

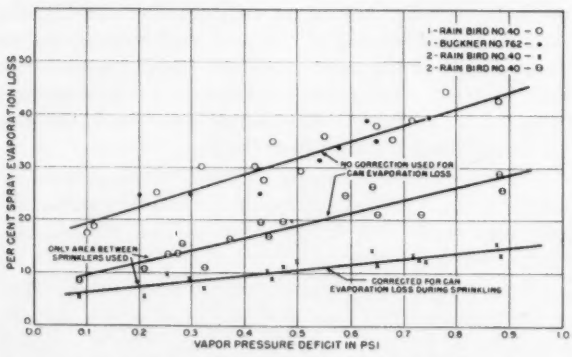
About 100 tests of 1 to 2 hr duration were first run with only a single sprinkler in the test area. Test runs were made in daytime and at night, at clear and cloudy weather under various temperatures, humidities, and wind conditions, and operating pressures. No corrections were made for evaporation loss from the water collected in the cans during the test period, since in previous work they had appeared to be negligible. Spray losses under extreme conditions of bright sunlight at high temperatures and low humidity ran as high as 35 to 45 percent. These results were in line with those reported previously by others under similar conditions.

It was suspected that, in operating a single sprinkler alone, losses in the outer fringe area were not comparable with those occurring under field conditions with overlapping spray from adjacent sprinklers. This was verified in following tests in which two sprinklers were operated and the losses were computed on the basis of the overlapping area between the two sprinklers. This arrangement, which closely similates field conditions with a row of sprinklers on a lateral, resulted in greatly reduced spray losses as shown by the comparative curve losses in Fig. 1.

In all of the test runs it was found that spray losses could be closely correlated with vapor pressure deficit of the atmosphere during the test period. The vapor-pressure deficit is equal to the difference between the vapor pressure of the moisture in the air and the vapor pressure at saturation

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Urbana, Ill., June, 1955, on a program arranged by the Soil and Water Division.

The author—K. R. Frost and H. C. Schwalen—are, respectively, associate agricultural engineer and agricultural engineer, agricultural experiment station, University of Arizona.


1 - RAIN BIRD NO. 40 - O
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2 - RAIN BIRD NO. 40 - ⊙
NO CORRECTION USED FOR CAN EVAPORATION LOSS
ONLY AREA BETWEEN SPRINKLERS USED
CORRECTED FOR CAN EVAPORATION LOSS DURING SPRINKLING
PER CENT SPRAY EVAPORATION LOSS
VAPOR PRESSURE DEFICIT IN PSI

Fig. 1 Relation of spray losses with 3/16 x 1/8-in nozzles to vapor pressure deficit under the following test conditions: *(top curve)* using a single sprinkler head without correction for can evaporation loss, *(center curve)* using two sprinklers and considering only the overlapping area between them with no corrections, and *(lower curve)* same as center but corrected for can evaporation

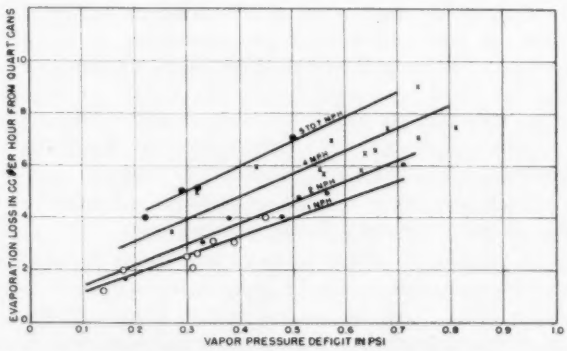


Fig. 2 Correction factor to be added to the catch in regular gage cans to compensate for evaporation from cans during test runs under bright sunlight conditions at various wind velocities. This correction is equal to the catch in regular cans at same locations

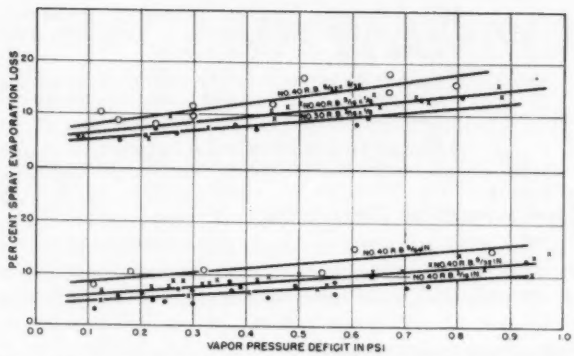


Fig. 3 The upper group of curves shows the comparative losses from two sizes of nozzles and two different sprinkler heads. The lower group shows the losses obtained from range nozzles of different sizes. All tests at less than 5 mph average wind velocity

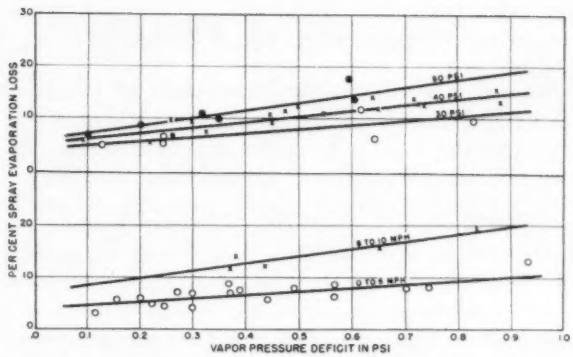


Fig. 4 The upper group of curves is a comparison of spray evaporation losses with two $\frac{3}{16}$ x $\frac{1}{8}$-in sprinkler heads at an average wind velocity of less than 5 mph. The two lower curves show the comparative losses at less than 5 mph and 8 to 10 mph with a $\frac{3}{16}$-in range nozzle at 40 psi

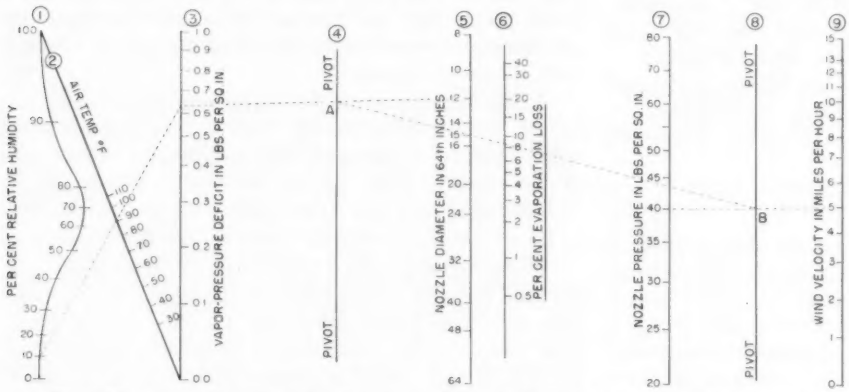

PER CENT RELATIVE HUMIDITY
AIR TEMP °F
VAPOR-PRESSURE DEFICIT IN LBS PER SQ IN
PIVOT
NOZZLE DIAMETER IN 64th INCHES
PER CENT EVAPORATION LOSS
NOZZLE PRESSURE IN LBS PER SQ IN
WIND VELOCITY IN MILES PER HOUR

Fig. 5 Nomograph for estimating the evaporation spray losses under various climatic and operating conditions in sprinkler irrigation

at the same air temperature. However, comparative losses at the same vapor-pressure deficit were found to be consistently higher on clear days than on cloudy days. It was evident that direct solar radiation was affecting the results. A check with a pyrheliometer showed that the difference in loss was not due to interception by the spray of the radiant heat of the sun.

Painting the gage cans white eliminated the greater part of the heat absorbed by direct solar radiation which resulted in greatly reduced evaporation losses. The use of oil in the cans further reduced these losses to a negligible amount during the test periods. The reduction in loss due to the use of oil in the cans is attributed to the fact that the first droplets striking the oil surface splashed a thin film on the inside walls of the cans. Succeeding droplets of water striking the sidewalls immediately flowed into the collecting reservoir below the oil surface.

From the standpoint of measuring the total catch it was impractical to use oil in all of the gage cans. Gage cans filled about one-half full with either diesel fuel or kerosene were placed adjacent to regular cans at between 5 and 7 different locations, depending upon wind conditions, to obtain an average correction factor for each test run. The bottom line in Fig. 1 shows the results obtained when this correction factor is applied to the losses from the regular gage cans when using a test area between two adjacent sprinklers. It is evident that losses formerly attributed to evaporation from the spray while in the air were actually due to loss which occurred after the water reached the gage cans. The average correction values required on bright, clear days at midday for various wind velocities are shown in Fig. 2.

Influence of Nozzle Size on Losses

A large number of tests, at the most common operating pressure of 40 psi, were run on Rain Bird No. 40 sprinkler heads, both with and without spreader nozzles. Test runs in this series were all made with wind velocities averaging less than 5 mph, but under a wide range in other weather conditions. Results shown in Fig. 3 indicate that evaporation losses vary inversely with the diameter of nozzle. Comparison of the No. 30 Rain Bird sprinkler with special type nozzle openings and the standard No. 40 with spreader pins shows lower losses with the former due to less breaking up of the stream as shown in the lower curve in the upper group in Fig. 3.

The lower group of curves shows the evaporation losses to be expected when only a range nozzle is used at 40 psi operating pressure. Individual test points indicate that losses as low as 3 percent may be expected at low vapor pressure deficits and with nearly zero wind movement and

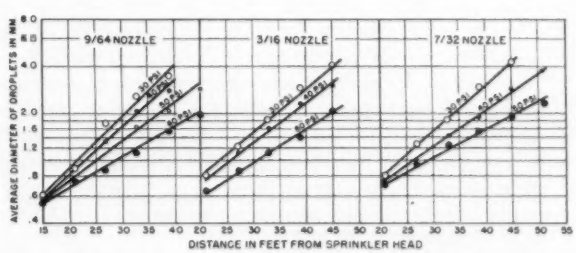


Fig. 6 Determination of droplet size in respect to distance from sprinkler head. Droplets were collected in cans partially filled with bentonite. By weighing cans before and after passes of the sprinkler and by counting the number of droplets in each can, the average diameter was computed

comparable losses on a hot, dry day may run up to 10 percent, as shown by the bottom curve in this group.

Influence of Nozzle Pressure on Losses

Nozzle pressures were varied from 20 psi for small low-angle sprinkler heads to 80 psi for large ½-in nozzles. Results of tests with Rain Bird No. 40 sprinklers equipped with 3/16 x 1/8-in nozzles and spreader pins at 30, 40, and 50 psi nozzle pressures and at low wind velocities are plotted in the upper group of curves in Fig. 4. Removing the spreader pins decreased losses by about one-fifth in tests under comparable conditions.

Under the higher pressures the streams issuing from the nozzle jets are broken up into much finer spray with correspondingly greater surface area. Both evaporation loss and wind drift losses are increased. Losses in general are about proportional to nozzle pressure, that is, increasing the pressure from 40 to 50 psi will give an increase of one-fourth in spray losses. This is especially apparent when significant losses occur under moderate and hot weather conditions.

Near the saturation point or at a very low vapor-pressure deficit, the losses were about 3 percent at 30 psi and noticeably greater at 50 psi, with the difference increasing with the vapor pressure deficit.

Influence of Wind Velocity

Tests were run on various nozzles and arrangements at 8 to 10 mph (average) wind velocity for comparison with those at 0 to 5 mph. Comparative results obtained at 0 to 5 mph and 8 to 10 mph are plotted in the lower half of Fig. 4 for 3/16-in nozzles at 40 psi nozzle pressures. Losses were considerably higher at the high wind velocities as much of the fine spray was carried out of the collecting area and therefore failed to reach the ground surface in measurable quantities. As this drift did not moisten the soil outside of the can area, it was assumed that it was a complete loss for irrigation purposes. Doubling the wind velocity approximately doubled the losses for all weather conditions for the nozzles used in these tests. Since average wind velocities were measured for the test period, peak velocities were no doubt 50 to 100 percent higher than those shown in Fig. 4.

Nomograph for Estimating Spray Losses

Evaporation spray losses from sprinklers are dependent upon both climatic factors and operating conditions. The following general conclusions are based upon some 700 test runs under a variety of climatic conditions. Losses increase with temperature, wind movement, operating pressure and degree of breaking of spray, and decrease with increase in humidity, and nozzle diameter. They are most directly related to the vapor-pressure deficit in the atmosphere which is dependent upon the temperature and relative humidity.

The nomograph in Fig. 5 has been prepared on the basis of the experimental tests and follows as closely as possible the relationships established in them. The use of the nomograph is explained by following through the example below:

Given: Single 3/16-in range nozzle, at 40 psi, average wind velocity 5 mph, air temperature 90 degrees F., and relative humidity 10 percent.

Object: Determine the estimated spray loss.

Method: 1 Draw a line from 10 percent relative humidity point on scale (1) through 90 degrees F. temperature on scale (2) and extend line to scale (3) giving a vapor pressure deficit of 0.63.

2 Then draw line from 0.63 on scale (3) to diameter of nozzle scale (5) at the 12/64 or 3/16-in mark, intersecting pivot line (4) at point *A*.

3 Connect 40 psi on scale (7) with the wind velocity of 5 mph on scale (9) with a line, intersecting the pivot line (8) at *B*.

4 Connect pivot points *A* and *B* intersecting scale (6) at the 8.3 percent evaporation point—the answer.

Measurement of Droplet Size

The total surface area of a given volume of water varies inversely as the diameter of the droplets. The smaller the droplet, the greater is the surface area exposed to the air and direct solar radiation and the greater the evaporation from the sprinkler spray.

A study was made to determine the approximate size of the droplets for a comparison of the computed theoretical evaporation loss with that determined experimentally. The results of the study as shown in Fig. 6 indicate that, for a given nozzle size, the diameter of droplet increases with the distance from the sprinkler head and varies inversely with the nozzle pressure.

It was found possible to measure the approximate size of the droplets by collecting them in cans partially filled with bentonite, weighing cans before and after 5 or 6 passes of the sprinkler and counting the number of droplets in each can after each pass. This enabled the average diameter to be computed for a given distance from the nozzle.

Computed evaporation losses from the spray based upon the total exposed water surface as determined from droplet sizes were considerably lower than the experimental losses, even though in the calculations it is assumed that the temperature of each droplet is reduced to the wet-bulb temperature by the time it reaches the ground surface. It is believed that the wind drift and loss of the extremely fine droplets accounts for at least part of this difference.

Engineering the Hillside Combine

(Continued from page 525)

soil with the steering wheels turned up a steep slope, and individual brakes are used to help steer.

Automatic leveling controls are, in themselves, a good safety device to guard against the operator leveling the wrong way and to help cut down "operator fatigue." The automatic controls should have a handy manual overriding control to guard against failure.

If hydraulic leveling is used, some method should be provided to prevent the breaking of a hydraulic line from letting the machine level over to the heavy side, such as pilot-operated check valves at the cylinder outlets. If mechanical leveling is used, it is well to have the drive through a low-helix angle, non-reversing worm.

Power steering helps decrease operator fatigue and in that way is a good safety device.

All controls should be placed in a natural and accessible location to cut down operator fatigue and to make it natural for the operator to actuate the proper control in the correct direction in case of emergency.

Thought and care must be given to the emergency-brake locking control to make it unlikely the operator will drive the machine with the brake on, as this has been the cause of many grain fields being set on fire.

Use of Water by Pasture Crops

Harold E. Gray, Gilbert Levine and W. K. Kennedy
Member ASAE · Assoc. Member ASAE

ONE of the prime elements in determining the irrigation requirements of any crop is the consumptive use of water by that crop. Various methods have been proposed for estimating consumptive use in areas where very few or no actual measurements are available. Of these, probably the best known are the methods suggested by Blaney and Criddle (1)* and Thornthwaite (2).

The Blaney and Criddle method considers temperature and the length of daytime hours as the two important factors affecting consumptive use. Although other factors such as humidity and wind will have an effect, they are not included as separate terms. These factors are generally correlated with temperature and day length, and are therefore included indirectly. This simplifies the computation of consumptive use.

The method proposed by Thornthwaite is an empirical formula which considers temperatures and latitude as the two primary variables in estimating evapotranspiration. Temperature records are readily available for most areas. To consider latitude, however, requires either some fairly involved computations or the use of nomographs.

Regardless of the method used for estimating consumptive use, it is only an expedient until sufficient measurements are available for use in determining irrigation requirements. A considerable amount of this information has been obtained in the west and southwest regions of the United States, but as yet few studies have been made in the eastern region under humid climatic conditions. To obtain some of this information, the authors studied the consumptive use of water in conjunction with an irrigation experiment on alfalfa and brome grass pasture that was conducted during the summers of 1953 and 1954. Results of the pasture irrigation experiment have been reported previously (3). The results of these consumptive-use studies are the subject of this paper.

Observations on the consumptive use of water in conjunction with an irrigation experiment on pasture land and under humid conditions

Paper prepared expressly for AGRICULTURAL ENGINEERING.

The authors—HAROLD E. GRAY, GILBERT LEVINE and W. K. KENNEDY—are, respectively, associate professor and assistant professor of agricultural engineering and professor of agronomy, Cornell University.

*Numbers in parentheses refer to the appended bibliography.

Experimental Procedure

Consumptive use of water was determined by soil moisture studies in the irrigated plots. Plaster of paris blocks were buried at 24 different locations, six different locations under each of the three levels of irrigation and six locations on the non-irrigated plots. Blocks were set at depths of 6 in, and at one, two, and three-foot depths at each location. Blocks were read on a schedule of three times a week throughout the seasons. Additional readings were taken just prior to irrigation and twenty-four hours after irrigation if these readings did not fall on a regularly scheduled day.

Meter readings were calibrated in the laboratory to per cent of moisture dry-weight basis for soil samples from the experimental area. For consumptive-use determinations, percentage of moisture was converted to inches of water per foot of depth using the apparent specific gravity (volume weight) of the soil.

Evaporation and rainfall were measured at the experimental site. The evaporation was determined by the use of a standard U.S. Weather Bureau evaporation pan (class A.). Rainfall was determined by a standard U.S. Weather Bureau rain gage. Temperature records were taken from the Caldwell Field Weather Station at Ithaca, New York.

The consumptive use of water for any period was determined by the formula

$$u=(M_1-M_2)+R+I$$

Where

u=the consumptive use in inches for the period (taken as a month except at the beginning of the season when the full month's records were not available)

M_1=totals inches of water in the soil at the beginning of the period

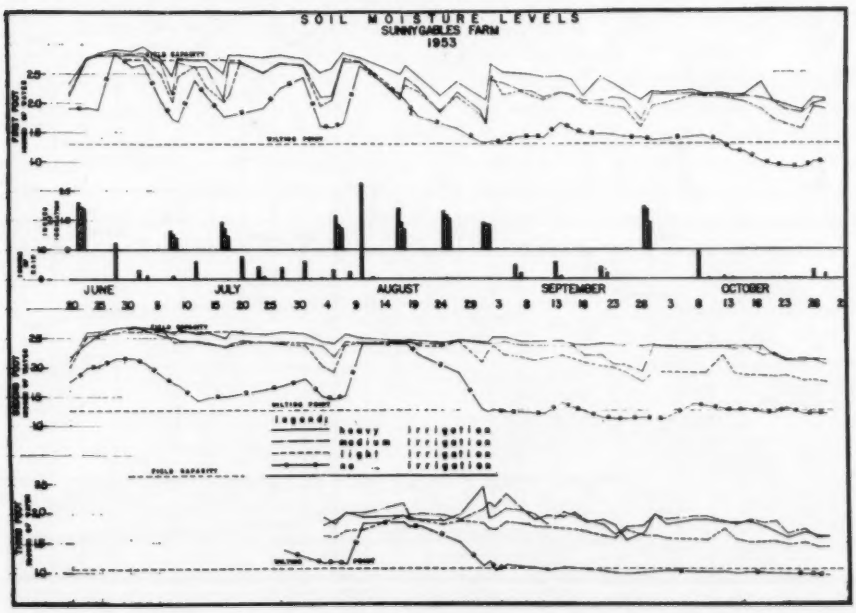


Fig. 1 Rainfall, irrigation, and soil moisture levels in 1953

M_2=total inches of water in the soil at the end of the period

R=total inches of rainfall (excluding runoff) for the period

I=total inches of irrigation for the period.

The field capacity of the soil at each depth was taken as the moisture equivalent as determined by the centrifuge method. The permanent wilting point was obtained by the pressure plate method.

Experimental Results

Soil moisture records were begun on June 20, 1953, and continued through October of that year. In 1954, the records were begun on May 5 and continued through Otcober. Rainfall, irrigation, and the total amount of moisture in each foot of soil for the two seasons are shown in Figs. 1 and 2. The general level of moisture in the soil was maintained at higher level in 1953 when a net depletion of one inch was allowed as compared to 1954 when a net depletion of 1½ in was allowed before irrigation. In 1953 the irrigation was scheduled on the basis of the average evaporation for a 20-year period; in 1954 the scheduling was on the basis of evaporation measured at the experimental site. Using this method of scheduling, the total moisture left in the soil just prior to irrigation was depleted to approximately the same level throughout each season (Figs. 1 and 2). This level was lower in 1954 when 1½ in were depleted than in 1953 when only one inch was depleted.

A summary of the consumptive use and measured evaporation is given in Table 1. Calculation of values for K in the Blaney-Criddle formula resulted in a seasonal value of K of 0.66 in 1953 and 0.56 in 1954.

An analysis of the consumptive-use records for 1953 showed that the maximum consumptive use for any ten-day period throughout the season was 2 in, or 0.20 in per day. In 1954 the maximum consumptive use for any ten-day period was 2.17 in, or .22 in per day.

TABLE 1. SUMMARY OF CONSUMPTIVE USE OF WATER BY IRRIGATED PASTURE

month	Daily consumptive use, in	Daily Evaporation, in	month	Daily consumptive use, in	Daily Evaporation, in
	1953			1954	
June 20-30	0.15	0.16	May 6-31	0.11	0.13
July	0.16	0.19	June	0.11	0.14
August	0.15	0.14	July	0.15	0.16
September	0.11	0.10	August	0.13	0.12
October	0.08	0.07	September	0.07	0.08
			October	0.07	0.07
Seasonal (132 days)	0.13	0.13	Seasonal (178 days)	0.11	0.12

The soil moisture data were used to determine the moisture extraction pattern for this meadow crop. An analysis was made from data taken during periods when the soil moisture was depleting and there was no rain or irrigation to maintain the moisture level. Hence the results indicate only the water that was transpired by the crop and that which evaporated from the soil. During the 1953 season, 57.9 per cent of this water in the three-foot soil zone came from the first foot, 30.0 per cent came from the second foot, and 12.1 per cent came from the third foot. In 1954, 50.3 per cent came from the first foot, 29.1 per cent came from the second foot, and 20.6 per cent came from the third foot. A higher proportion of the total water used would be shown as coming from the first foot if all periods were considered.

Discussion of Results

The use of an evaporation pan for determining the time to irrigate offers many interesting possibilities. The very close agreement between the measured evaporation and the consumptive use throughout both seasons is evident from

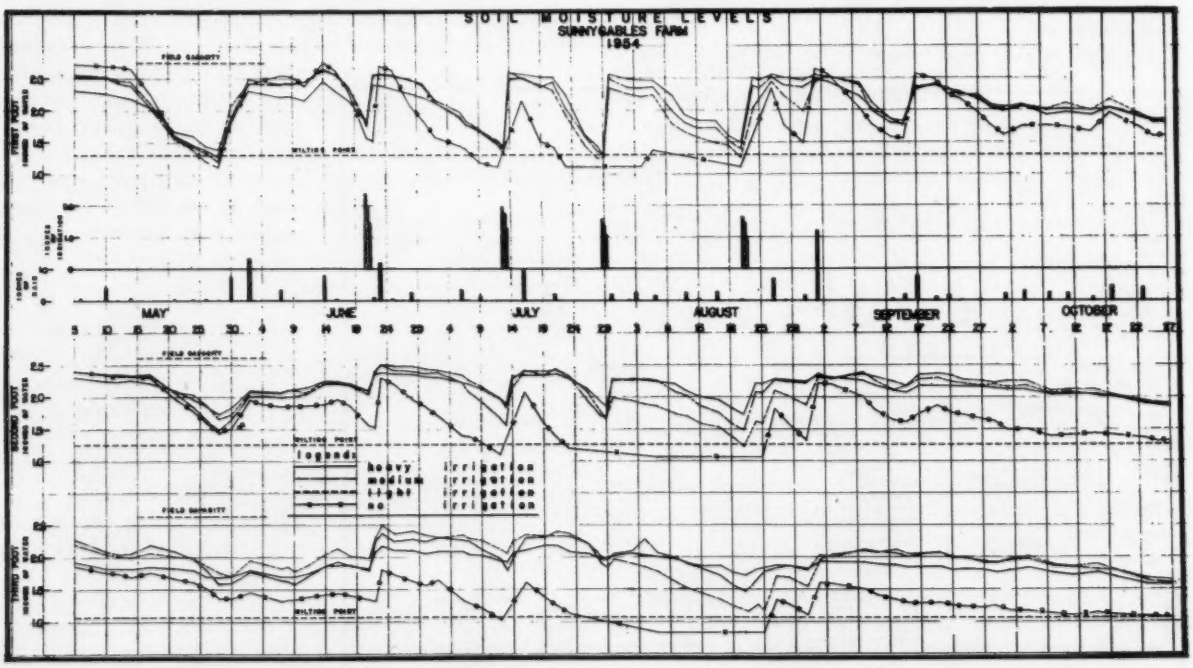


Fig. 2 Rainfall, irrigation, and soil moisture levels in 1954

Table 1. Further evidence of the close agreement is the fact that, by allowing a predetermined net depletion, the amount of the moisture in the soil just prior to irrigation was brought to the same level each time. This depletion value would be selected upon a consideration of the available water capacity of the soil, the crops to be irrigated, and the amount of irrigation equipment.

In scheduling the irrigation, an application of the total amount depleted should replenish the entire capacity of the soil to hold water. This is exemplified by the rise in soil moisture content to field capacity in Figs. 1 and 2. In very dry regions, the practice of applying the entire net depletion as measured by the evaporation pan should be a desirable practice.

When rainfall occurs, not all of the rain can be used effectively if the soil moisture is at a high level. The authors have pointed out previously (3) that the small difference in consumptive use between the high and low irrigated plots could be explained by the fact that the low-level plots had more water-storage capacity available for rain and could make more effective use of this rain. Thus in humid regions, where some rainfall can be expected throughout the growing season, it would seem practical to apply by irrigation only a certain fraction of the net water depletion measured by the evaporation pan. On the basis of evidence obtained from this experiment, a value of 75 per cent would seem desirable for this fraction. This can be varied for individual situations. If the rain does not come, the evaporation pan will indicate the design depletion in a shorter time interval than originally designed for, and equipment will have to be operated longer per day to cover the area. The use of a fraction of the water depletion, however, aids in the more effective use of rain, while protecting the grower from complete moisture depletion by the more frequent scheduling.

From a practical standpoint, the evaporation pan offers a number of advantages. It is a relatively simple and inexpensive device. Although a hook gage was used to obtain the information in this experiment, a simple ruler or even markings on the pan would be sufficiently accurate for the practical irrigator. The evaporation pan will integrate the effects of all the factors such as wind and humidity that also affect consumptive use. The pan will automatically subtract the evaporation and add the rainfall. After irrigation, the amount of the irrigation application could be added to the pan. One problem that arises is that of excess rainfall that is more than sufficient to replenish the soil moisture. An overflow at the proper level in the pan would take care of this problem. Thus excess water would drain off the pan much the same as runoff of excess water from the soil.

Values for K for use in the Blaney-Criddle formula have previously been reported as varying from 0.64 to 0.91 on pasture (1). The values obtained in this experiment are slightly lower. These lower values would be expected in a region with relatively higher summer rainfall. An important point to consider is the variation in the consumptive use determined for two different seasons. Even though the temperatures were not far different, the consumptive use varied by approximately 15 per cent. Moreover, this closely approximated the variation in evaporation. This further emphasizes the fact that some direct measurement of consumptive use in the region concerned is more accurate than the application of a formula derived from conditions in another area.

The maximum consumptive use for a ten-day period was considerably higher than either the seasonal averages or even the monthly averages. In areas where very little rain falls for long periods, these maximum values would be important for design consideration. However, in humid regions, the maximum monthly average should be a safe design value.

The soil moisture studies would indicate that, under irrigated conditions, even the deep-rooted alfalfa and brome grass pasture obtained the majority of its required water from the first two feet of soil, with water being drawn from greater depths as the moisture content was depleted. In 1953, when the moisture content was maintained at a higher level than in 1954, a larger proportion of the moisture was drawn from the upper two feet.

During both seasons there were periods when the moisture was depleted from the third foot under the non-irrigated pasture. Since some growth continued even without irrigation, it is logical to assume that these plants were extracting moisture from below the third foot. Under the irrigated plots, it was possible to satisfy the water needs of the crop in the first three feet of the soil.

Summary and Conclusions

Results have been presented on the consumptive use of water by irrigated pasture in a humid climate. The average daily consumptive use for the 1953 season was 0.13 in per day; in 1954 it was 0.11 in per day. The highest average daily consumptive use for any month was 0.16 in in 1953 and 0.15 in in 1954. The maximum average daily consumptive use for a ten-day period in 1953 was 0.20 in; in 1954 it was 0.22 in.

The evaporation-pan method of scheduling irrigation offers considerable promise. When properly used it gives accurate results, and it is simple and inexpensive to construct and operate.

The measured evaporation and the consumptive use were approximately equal throughout both seasons. In scheduling irrigation in arid climates, it would seem advisable to apply 100 per cent of the soil moisture depletion as determined by the evaporation pan. In humid climates, 75 per cent of this value could be used.

Under the conditions of this experiment, it was possible to satisfy the water needs of the pasture crop in the top three feet of the soil. However, it was evident that the crop that was not irrigated was extracting water from below the three-foot depth.

References

1 Blaney, H. F., and W. D. Criddle Determining water requirements in irrigated areas from climatological and irrigation data, U.S. Dept. of Agr., Soil Conservation Service, Tech. Bul. 96, 44 pp.

2 Thornthwaite, C. W. An approach toward a rational classification of climate, *The Geographical Review*, 38:55-94, 1948.

3 Levine, G., W. K. Kennedy, and H. E. Gray, Irrigation of Pastures, AGRICULTURAL ENGINEERING, vol. 36, July, 1955.

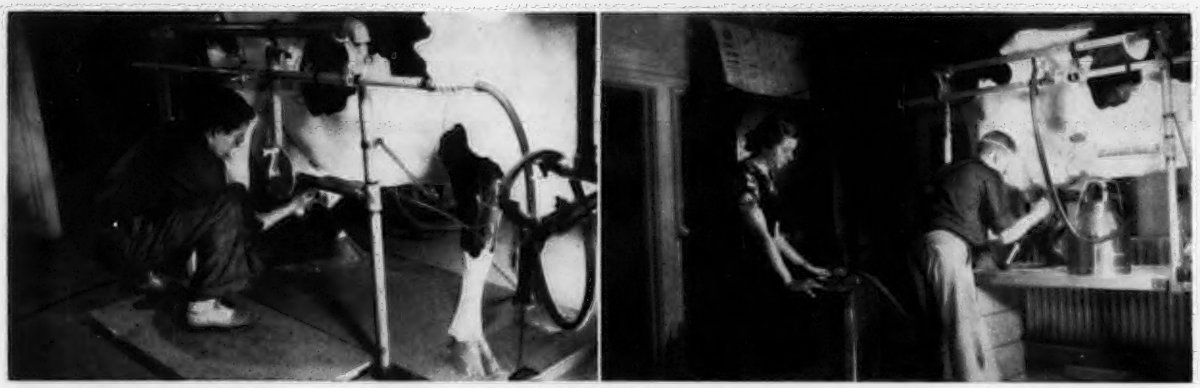


Fig. 1 Two views of milking laboratory at Cornell University. *(Left)* Operator preparing cow for single-level layout with work area • *(Right)* Operator applying milking unit. Equipment for measuring oxygen consumption is also shown

Time and Effort to Milk Cows

W. H. M. Morris and L. L. Boyd
Assoc. Member ASAE Member ASAE

MOST of the many studies made of the milking of cows in the field and in experimental herds have failed to show significant differences between the layout and the time involved, because the great variability among operators and among cows masked the differences between the "treatments" observed. The differences may be in time or in effort, the two physical inputs of labor in milking.

A milking laboratory was set up at Cornell University in 1952 to study the differences between the time and effort required to milk cows with different arrangements of the milking area and different milking machines; the experimental design and conditions reduced the effect of the variability due to the operator and due to the cow. The carrying and straining of milk was investigated separately.

Results of laboratory study reveal significant information on time-and-effort-saving possibilities of various milking-equipment combinations

TABLE 2. CORRECTED TREATMENT MEANS FROM RESULTS OF MILKING LABORATORY STUDY (Cornell University, 1952)

		Buckets					Pipe line	
		Regular		Double	Suspended		Regular	Suspended
Layout	Element	from right side	from left side		with sircingle	with bracket		
Single level, no work area	Prepare	.29	.33	.28	.29		.34	
	Apply	.31	.42	.37	.54		.25	
	Remove	.15	.16	.15	.22		.13	
	Travel	.39	.59	.45	.47		.44	
	Total	1.84	2.20	1.95	2.22		1.86	
	Effort	205.9	145.3	167.5	132.7		156.5	
Single level, with work area	Prepare	.33			.33		.31	.31
	Apply	.35			.40		.23	.23
	Remove	.17			.21		.11	.12
	Travel	.30			.32		.26	.24
	Total	1.85			1.96		1.61	1.60
	Effort	193.1			166.5		152.2	165.0
Cow standing 16 in above work area	Prepare	.29				.28	.33	.30
	Apply	.37				.36	.23	.22
	Remove	.15				.18	.12	.10
	Travel	.29				.27	.25	.26
	Total	1.80				1.79	1.63	1.58
	Effort	159.8				129.4	176.1	191.6
Cow standing 28 in above work area	Prepare	.30				.36	.30	.29
	Apply	.33				.34	.20	.21
	Remove	.15				.19	.11	.11
	Travel	.28				.29	.23	.23
	Total	1.76				1.88	1.54	1.54
	Effort	185.0				183.8	192.5	104.8
Cow standing 32 in above work area	Prepare	.30				.27	.33	.28
	Apply	.35				.31	.23	.22
	Remove	.14				.16	.10	.10
	Travel	.27				.31	.32	.22
	Total	1.76				1.75	1.68	1.52
	Effort	107.8				141.1	136.2	144.4
Cow standing 36 in above work area	Prepare	.32				.28	.35	.33
	Apply	.33				.31	.23	.21
	Remove	.15				.16	.11	.11
	Travel	.30				.29	.30	.23
	Total	1.80				1.74	1.69	1.58
	Effort	98.5				108.2	93.3	106.6

Equipment and Layout

A full-sized model of a Holstein cow was fitted with rubber teats and mounted on a platform. The platform was supported on blocks to give a range of five elevations from 0 to 36 in above the floor of the work area (Fig. 1).

Five different types of milking units were used:

- Regular bucket
- Regular bucket with two sets of teat cups

Revised paper, submitted in its original by the senior author in competition for the 1953 ASAE Graduate Student Paper Award. The paper described in part the work done by the authors under Research and Marketing Project No. 32, Cornell University Agricultural Experiment Station.

The authors—W. H. M. Morris, and L. L. Boyd—are, respectively, formerly research assistant in agricultural engineering, Cornell University, now assistant professor of agricultural economics, Purdue University, and associate professor of agricultural engineering, Cornell University.

- Suspended bucket
- Regular pipe line
- Suspended pipe line.

The short-tube suspended milkers were modified by fitting longer vacuum tubes to the teat cups, making it easier to apply them to the somewhat rigid udder.

The combination of treatments selected is shown in Table 1. The number of treatments was made up to twenty-five to facilitate the use of a lattice square design. The tests were run in groups of five performed by one operator. Six operators were observed. The layout enabled correction of the results for differences between days as well as between operators. It also eliminated any bias due to fatigue as the tests progressed. It gave a higher degree of accuracy than randomised blocks or latin squares for a similar number of replications.

TABLE 1. TREATMENTS IN THE MILKING LABORATORY LATTICE DESIGN PLATFORM LEVEL

	Machines				
	Bucket			Pipe line	
	Regular	Double unit	Sus-pended	Regular	Sus-pended
Single level, no work area	XX	X	X*	X	—
Single level, with work area	X	—	X†	X	X†
16 in above work area	X	—	X†	X	X†
28 in " " "	X	—	X†	X	X†
32 in " " "	X	—	X†	X	X†
36 in " " "	X	—	X†	X	X†

*With sircingle
†With bracket support

The single-treatments represent conditions in a stanchion barn with no work area and in a single-level parlor with a work area. The suspended-pipe-line unit was not suitable for suspension from a sircingle and so was not used in the single-level treatment with no work area.

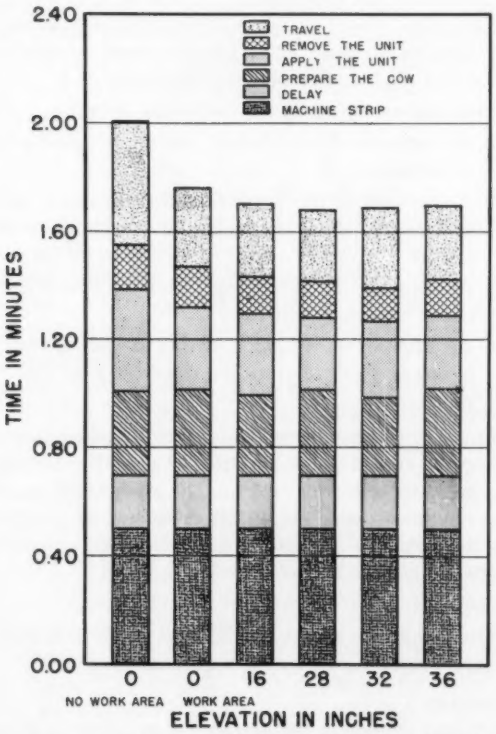


Fig. 2 Average cycle times for different elevations subdivided into elements (stages of milking operation)

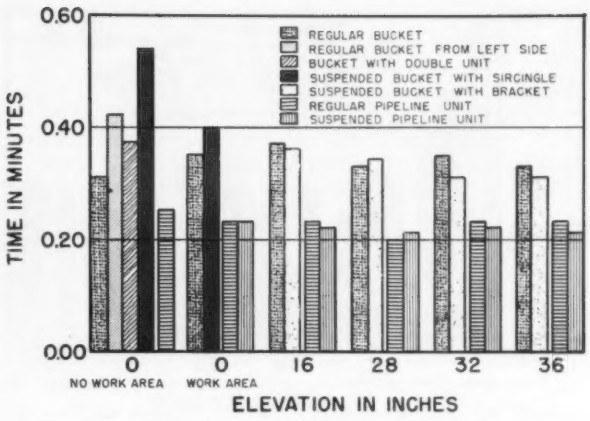


Fig. 3 Time for different treatments in applying milking unit

Instrumentation. The times were recorded by a kymograph designed specially for this study (5)*. The cycle was broken down to the smallest components that could be timed visually and records were kept to the nearest 1/100 min.

The measurement of effort was comparative and not absolute. It was made by comparing the rates of oxygen consumption estimated from the curves of a Sanborn closed-circuit metabolism tester (1). The tester was mounted on a carriage and fitted with long rubber hoses; an assistant was responsible for keeping the machine close to but out of the way of the operator (Fig. 1). The measure of effort was considered to be the ratio of the increase in rate of oxygen consumption when working to the rate when standing at rest; this was converted to a percentage. The operators expressed no discomfort when wearing the equipment. The results indicate that the tests made with this equipment took no longer than those in which the equipment was not worn.

Laboratory Procedure

The standard routine to be followed was carefully established with the department of animal husbandry of Cornell University. Every effort was made to maintain the same procedure throughout all the tests; the details are recorded elsewhere (6).

Each test was run four times, twice without and twice with the metabolism tester. The average of the four tests was used in analysis. Since each treatment was replicated

*Numbers in parentheses refer to the appended bibliography.

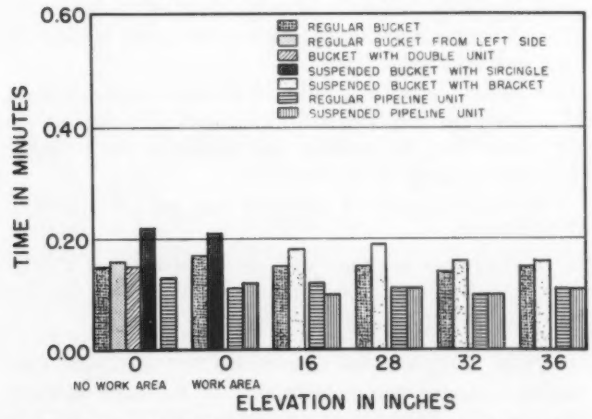


Fig. 4 Time for different treatments in removing milking unit

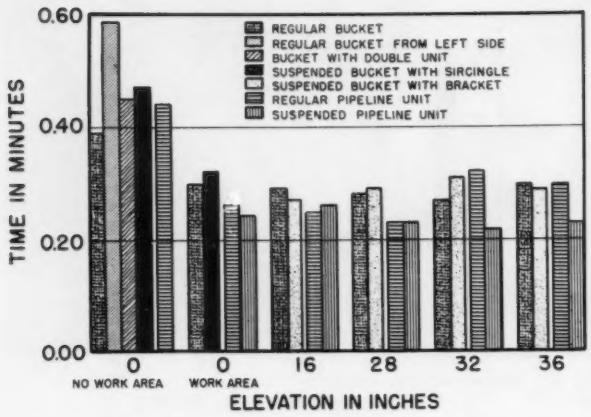


Fig. 5 Total travel time for different treatments

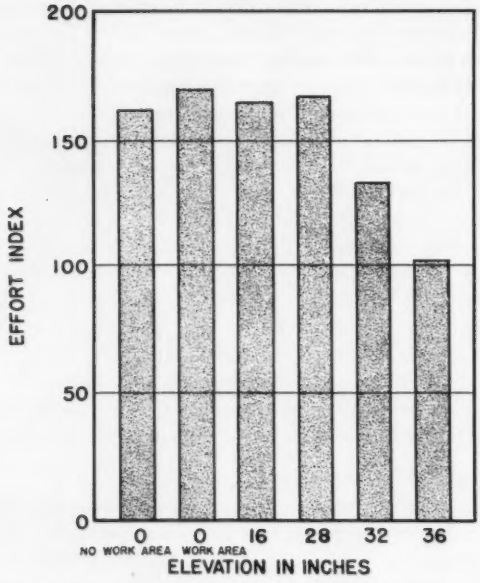


Fig. 7 Average effort index for different layouts

four times, the treatment mean is the result of 16 separate cycles. The routine was divided as follows:

- *Preparing the cow* included preparing the udder to simulate letdown and the use of the strip cup.
- *Applying the unit* included suspending or setting down the unit, applying the vacuum, and putting the teat cups on the udder.
- *Removing the unit* included removal of the teat cups from the cow, also, where applicable, uncoupling the unit from the vacuum line, removing the sircingle, and picking up the unit.
- *Travel* included all the travel time going to and from the cow.
- *Total time* was the cycle time corrected to give a delay of 0.2 min after returning from applying the unit and 0.5 min machine stripping.

Effort rating was the ratio of the rate of oxygen consumption during the cycle to that of the same operator standing still, expressed as percentage.

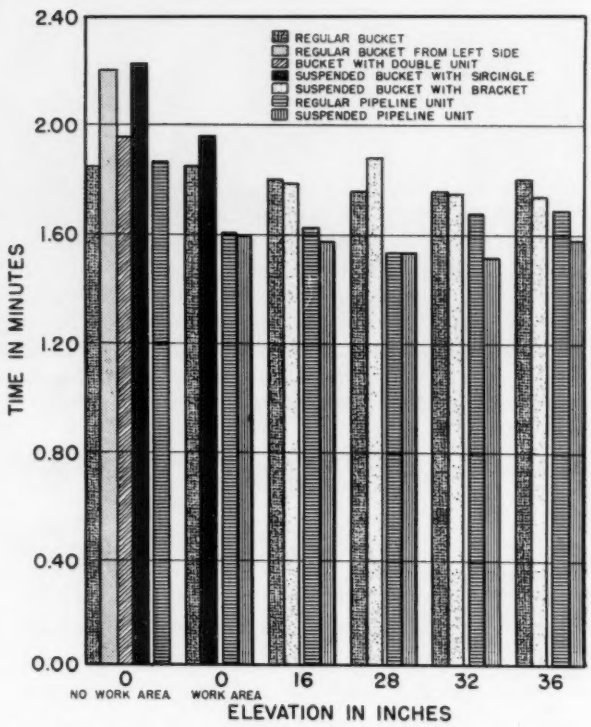


Fig. 6 Total cycle times corrected to standard delay time of 0.2 min and standard machine stripping time of 0.5 min

The Analysis

The analysis was made by confounding the day-to-day differences and the differences between workers with rows and replicates and by confounding the fatigue effect with columns. The procedure for this particular case is described by Federer and Robson (3). The computations were made on punched cards as described by Hoemeyer (4).

The analysis involved the following steps:

- An analysis of variance of the results as they stand uncorrected
- An analysis of the intrarow and intracolumn sums of squares and determining row and column weighting factors.
- Addition of the weighting factors to obtain the corrected treatment figures.
- An analysis of variance of the corrected treatment means and determining the significance of the differences.

Since the corrected treatment means lost their independence by the correction, to be strictly valid, they should not have been subjected to the normal analysis of variance. However, since there was no better method of comparison (3), an analysis of variance was made. This limitation of the analysis should be understood.

Results

The results are shown in Table 2. Their statistical significance was estimated by the sequential range test.

Discussion

Design. Although the design was excellent in reducing the variability from differences between operators, between

days, and fatigue caused by the tests, more time spent in experimentation could probably have saved time in the analysis. Each replicate took five hours to complete in the laboratory with a staff of four people. In any future experiment using this layout two more replicates would be used, making the lattice balanced; balance is achieved by $(n-1)/2$ replicates or any multiple thereof, where there are n^2 treatments.

The layout was split, two replicates being done by college students and two by high school students; it could be analyzed to show any difference between these groups. A preliminary experiment should have been made to investigate the necessity of this; in fact, the variability between the students was greater than the variability between the groups.

Results. The element "prepare the cow" was dependent only upon the layout and was, therefore, considered separately. The difference in time taken for this element was not significant for the various elevations of the cow above the work area. The average cycle times for different elevations are shown in Fig. 2, subdivided into elements (stages of milking operation). The machine stripping time of 0.5 min and the delay time of 0.2 min were common in all cases. The layout with no work area was not comparable since some machines used in this case were not used in others. The cycle time for this layout was longer than for that of the others; this was mostly because of the greater travel distance which resulted in a longer travel time.

The treatment differences were very similar for the time of the elements for applying and removing the unit (Figs. 3 and 4). Differences between times for the same machine used with different layouts were not significant; however, some differences between the times for different machines were significant. Milking with the suspended bucket with the sircingle required the longest time to apply and remove, because of the additional motions required to handle the sircingle. Milking with the bucket machines required significantly longer times than the pipe-line machines.

The travel times (Fig. 5) were slightly† shorter with pipe-line units than with bucket units, probably because the bucket units were carried for part of the travel time.

The complete cycle times (Fig. 6) showed relatively small differences with elevation, but the differences between the times taken with bucket and with pipe-line units were significant. Since the element time differences between the treatments tend to reinforce each other and not to counterbalance, any differences that appeared significant at the element level were also significant in the cycle times. Any differences that may exist in the machine stripping times with different machines in the field were eliminated from the laboratory studies. This might affect the cycle time in the field.

In contrast to the times, the effort rating was not significantly different for different machines with the same layout. The rating differed significantly between the 32-in elevations and between these and the other layouts (Fig. 7). The carrying of milk which would have altered the index was not included in this study.

The variance of the different factors analyzed fell between 7.6 and 21 percent. This is normal for studies involving human material, but the extra replicates obtained by balancing the lattice design would have helped to reduce the standard errors and so the variance.

†Significant only with 95 percent probability.

CONCLUSIONS

Time would have been saved by using a balanced lattice design, requiring $(n+1)/2$ replicates or any multiple thereof, where n^2 is the number of treatments. The unbalanced design used had four-replicates, which caused much additional computation.

The total time to milk the cow in the laboratory was significantly less with pipe-line units than with bucket units, apart from caring for the milk. Milking with the suspended bucket took longer than with the regular bucket, the difference being mainly in the element "remove the unit". No allowance was made for any difference that may exist in the machine stripping time. The difference in the time to milk with the regular pipe line and with the suspended pipeline units was not significant.

The times to milk the cow at the various elevations above the work area did not differ significantly.

The effort required to milk with 32 and 36-in elevation was significantly less than for all others. The effort with 36-in elevation was also significantly less than with 32-in.

The optimum height might be 36 in or even greater. This will depend upon the elbow height of the operator and on the type of stall; stalls which allow the cow to stand away from the operator (as in a lane-type parlor) should not be quite as high as those which keep the cow close to the work area (side-opening stalls).

BIBLIOGRAPHY

1 Anon. Sanborn metabolism tester, Sanborn Co., Cambridge, Mass.

2 Federer, W. T. Analyses for a 5x5 lattice square in 2 replicates and in 4 replicates. BU-27-M, June 1952, Cornell University Biometrics Unit.

3 Federer, W. T. and Robson, D. S. General theory of prime-power lattice designs, VI. Incomplete block design and analysis for p^5 varieties in blocks of p^2 plots. Cornell University Agric. Expt. Sta. Memoir 309:1952.

4 Hoemeyer, P. G., Clem, M. A., and Federer, W. T. Punched card and calculating machine methods for analyzing lattice experiments including lattice squares and the cubic lattice. Iowa Agric. Expt. Sta. Res. Bul. 347:27-171, 1947.

5 Morris, W. H. M. A kymograph, AGRICULTURAL ENGINEERING: 34;412, June, 1953.

6 Morris, W. H. M. The milking of cows: a methods study. Ph.D. thesis, Cornell University Library, 1953.

Engineering Enrollment Up

ENROLLMENT in college engineering has increased for the third consecutive year – after successive annual declines from a post-World War II high of 244,390 in the fall of 1947 to a post-World War II low of 147,894 in the fall of 1951, according to a report in the *Journal of Engineering Education,* February, 1955, by W. A. Jaracz and H. H. Armsby.

There were 187,454 engineering students enrolled in schools accredited by the Engineers' Council for Professional Development in the fall of 1954, an increase of 9.1 percent over the number enrolled in such schools in the fall of 1953. Although this increase is significant, it is somewhat smaller than the increase experienced by all institutions of higher learning, in which total enrollment increased 11.1 percent and male enrollment increased 11.8 percent.

NEWS SECTION

Nominations for 1956 ASAE Gold Medal Awards

IN ACCORD with the rules governing the award of the John Deere and Cyrus Hall McCormick Gold Medals, the Jury of Awards of the American Society of Agricultural Engineers will receive from members of the Society, up to November 1, nominations of candidates for the 1956 awards of these two medals.

The Jury of Awards desires that members of the Society consider it their duty and obligation to give serious thought to the matter and nominate for either or each of these awards the men they believe to be most worthy of the honor. Each nomination must be accompanied by a statement of the reason for nominating a candidate and qualifications of the nominee, including his training, experience, contributions to the field of agriculture, a bibliography of his published writings, and any further information which might be useful to the Jury in its deliberations.

The Jury will consider nominations received on or before November 1, and these nominations should be addressed directly to the Secretary of the Society at St. Joseph, Michigan. The Secretary will supply on request a standard set of instructions for preparing information in support of nominees for the Society's gold medal awards; in fact, it is important that these instructions be followed in preparing material on behalf of any nominee.

Student Paper Award Winners

GERALD ZACHARIAH, Kansas State College, was named first place winner in the student paper awards contest at the annual meeting of the American Society of Agricultural Engineers.

Second place in the contest went to James E. Bradley, Oklahoma A & M College, and third place to Virgil H. Lucke, Ohio State University.

The winning paper was presented as a feature of the general session immediately following the presidential address. Subject of the paper was "Strain Gage Measurement of Draft".

The second place paper by James E. Bradley was entitled "Natural Wind Ventilation of Wheat Grain", while Virgil H. Lucke's subject was on "Corn Husking Investigations".

Each of the three top national winners were previously selected by the ASAE Committee on Student Paper Awards from among papers submitted from student branches all over the country. They gave their papers orally before three past-presidents for final selection: G. B. Nutt, C. E. Seitz and S. M. Madill.

ASAE Meetings Calendar

August 22-24—NORTH ATLANTIC SECTION, University of Connecticut, Storrs

September 9 and 10 — NORTH CAROLINA SECTION, Morehead City, N. C.

October 19-21—PACIFIC NORTHWEST SECTION, Portland, Ore.

October 20-21 — PENNSYLVANIA SECTION, Holiday Motor Hotel, Gettysburg, Pa.

November 4 and 5 — VIRGINIA SECTION, Hotel Roanoke, Roanoke, Va.

December 12 to 14 — WINTER MEETING, Edgewater Beach Hotel, Chicago

June 17-20—49TH ANNUAL MEETING, Hotel Roanoke, Roanoke, Va.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

New Officers of National Council of ASAE Student Branches

MEMBERS of the Student Branches of the American Society of Agricultural Engineers assembled at the Society's 48th Annual Meeting at Urbana in June elected the following new officers of the Council for the 1955-56 year:

President — William Thompson, North Carolina State College

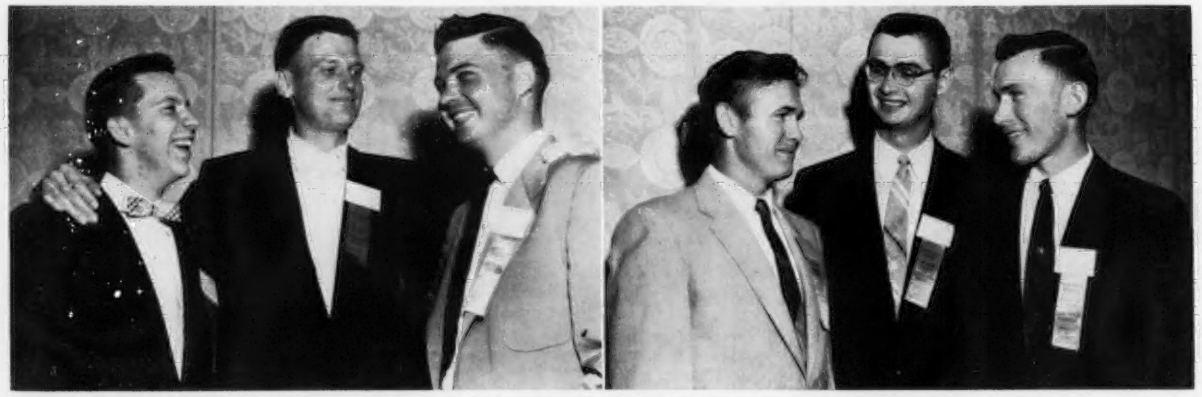
1st Vice-President—Irvin Eickmeyer, University of Illinois

2nd Vice-President — Clifford Chudleigh, A. & M. College of Texas

Secretary—Arvid Forsman, University of Maine

These officers were installed following their election on June 15.

The family outing included a chicken barbecue held in the concourse of the Illini Memorial Stadium, Monday evening, June 13, during the 1955 ASAE annual meeting. Snapped while being served were Mr. and Mrs. G. E. Pickard and Mr. and Mrs. C. A. Kincaid



(Left) Newly elected officers of the National Council of ASAE Student Branches, at the 1955 ASAE annual meeting. *(Left to right)* Arvid Forsman, University of Maine, secretary; Irvin Eickmeyer, University of Illinois, first vice-president, and William S. Thompson, North Carolina State College, president. • *(Right)* 1955 ASAE student paper award winners. *(Left to right)* James E. Bradley, Oklahoma A & M College, second place winner; Virgil H. Lucke, Ohio State University, third place winner, and Gerald Zachariah, Kansas State College, first place winner.

Blue Ribbon Awards for Annual Meeting Exhibits

ANNOUNCEMENT of extension exhibit blue ribbon winners at the 1955 ASAE Annual Meeting has been made by C. V. Phagan, chairman, Committee on Extension. Displays were provided by industrial and public service organizations all over the country.

Exhibits were displayed and judged according to type and class of entry. Classes included motion pictures, publications (bulletins and periodicals), slides and film strips, demonstration models, new textbooks, extension methods, and radio and television material. Entries were also divided into industrial and public agency groups. Blue ribbons were awarded for exhibits judged best in each class and by group.

Movie awards, under the direction of B. Parker Hess, were won by three films in the industrial group and one in the public agency group. The industrial winners were "Farm Family American," produced by General Electric Co., entered by J. H. Oliver; "Weather or Not," by National Plant Food Institute, entered by J. S. Greene; and "Pole-Type Buildings Cut Farming Costs," by Koppers Co. Inc., entered by W. J. Catrow. The public agency winner was "Yarn about a Kitchen," produced by Iowa State College and entered by K. L. McFate.

Slide and film strip entries were in charge of E. A. Olson. Blue ribbon winners for slides were "Concrete Farm Fire Cistern," University of Nebraska, entered by W. D. Lutes, and "Repair of Rusted Roofs," American Zinc Institute, entered by L. E. Bradley. Film strip winners included "Building Farm Fences," Southern Association of Agricultural Engineers and Vocational Agriculture, entered by G. E. Henderson, and "Build a Woven Wire Fence and Special Fence Problems," Republic Steel Corp., entered by E. D. Merrill.

Publications were in charge of Arnold Nicholson and were divided into industrial bulletins, public agency bulletins and industrial periodicals.

Industrial bulletin winners included "Materials Handling-Newest Farm Science," *Successful Farming*, entered by S.S. DeForest; "Bulk Handling of Milk with Stainless Steel," U.S. Steel Corp., entered by D. W. Derber, and "How to Modernize your Dairy Barn," General Electric Co., entered by J. H. Oliver.

Public agency bulletin winners included "Plan your Farmstead," University of Wyoming, entered by R. O. Gilden; "Irrigation, Structures and Methods for Water Control," Washington State College, entered by P. K. Fanning; and "Planning your Farmstead," University of Illinois, entered by K. H. Hinchcliff.

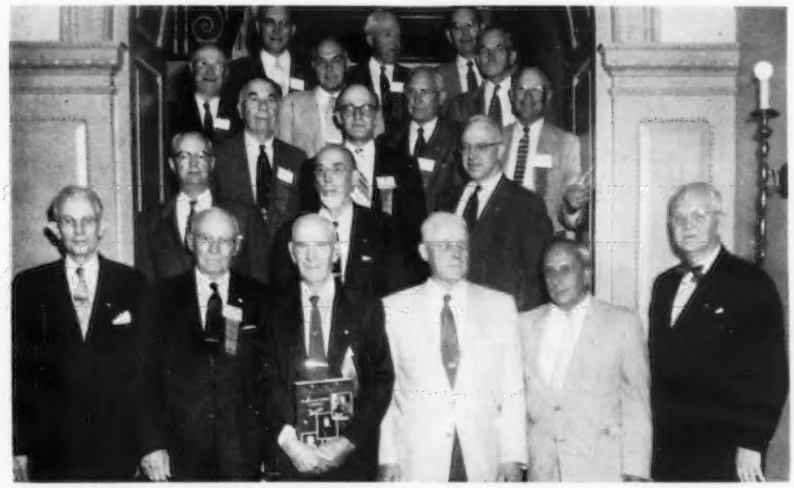
Winners in the industrial periodicals included "Rural Concrete Builder," Portland Cement Assn., entered by T. E. Long; "Crop Conditioning and Storage News," Krop-Kare Products Div. of Kilby Steel Co., entered by J. R. Mayner; "Quonset Farmstead News," Stran-Steel Div., Great Lakes Steel Corp., entered by E. D. Anderson, and "Gulf Farm Review," Gulf Oil Corp., entered by C. E. Kramb.

Several entries of demonstration models, under the direction of F. W. Andrew, received a great deal of visitor attention. A model tobacco barn by the Reynolds Metals Co., entered by C. H. Jefferson; a one-story dairy unit by Weyerhaeuser Sales Co., entered by K. C. Olson; self-feeding hay keeper, Iowa State College, entered by R. W. Hansen; and "Good Fences Need Good Corners," North Dakota Agricultural College, entered by G. L. Pratt, were the blue ribbon winners.

Among the extension method outlines exhibited under the direction of R. L. Ricketts, winners were the Colorado A & M College tractor maintenance one-day school, entered by O. J. Trenary; Iowa State College water system clinic, entered by K. L. McFate; Iowa State College fire safety clinic, entered by T. L. Willrich; and "4-H Electricity Judging and Identification School and Contest," by University of Wisconsin, entered by C. H. Neitzke.

New for 1955 was the section devoted to radio and television under the direction of D. P. Brown. Two films for TV were blue ribbon winners: "Painting Concrete Masonry," by Portland Cement Assn., entered by T. E. Long, and "Storm Windows Save Fuel Dollars," by Pennsylvania State University, entered by B. S. Horne.

Fifty textbooks were entered in that section of the exhibit under the direction of



A goodly number of past-presidents were on hand at the 1955 ASAE Annual Meeting held in June at Urbana, Ill. Left to right, *(front row)* Raymond Olney, 1919; William Boss, 1928-29; J. B. Davidson, 1908; G. W. McCuen, 1934-35; C. E. Seitz, 1932-33; E. W. Lehmann, 1923. *(Second row)* S. P. Lyle, 1938-39; H. W. Riley, 1912; J. D. Long, 1945-46. *(Third row)* A. P. Yerkes, 1937-38; E. W. Tanquary, 1953-54; O. W. Sjogren, 1926-27; W. G. Kaiser, 1929-30. *(Fourth row)* H. B. Walker, 1942-43; A. J. Schwantes, 1948-49; F. C. Fenton, 1950-51. *(Top row)* S. M. Madill, 1951-52; I. D. Wood, 1952-53; L. J. Fletcher, 1931-32

The presentation of Farm Equipment Institute trophies and citations to ASAE Student Branches at the 1955 ASAE annual meeting. *(Left)* Daniel Van Duyne, president of Pennsylvania Student Branch of ASAE, receives Group A trophy from R. L. Cade, chairman of ASAE committee on FEI trophies. *(Left to right)* Ronald Leonard, Iowa State College; Daniel Van Duyne; Bruce Lourie, FEI president; R. L. Cade; and Lester Hammond, University of Maine. Iowa State College and University of Maine were citation winners in Group A branches. • *(Right)* William Thompson accepts trophy for North Carolina State College as winner of the Group B trophy. Oklahoma A & M College and University of Missouri were citation winners. *(Left to right)* Kenneth Campen, University of Missouri; William Thompson; Bruce Lourie; R. L. Cade; and James Bradley, Oklahoma A & M College

J. P. Schaenzer. Due to the wide range of subject matter and the time required to make a fair comparison of these works, no awards were made in this class.

SAE Golden Anniversary Tractor Meeting

THE Golden Anniversary Tractor Meeting and Production Forum of the Society of Automotive Engineers will be held September 12 to 15, at the Hotel Schroeder, Milwaukee, Wis.

Opening day will be devoted to the production forum consisting of seven panels meeting concurrently. Panel topics include tool design, quality control, heat treating and manufacturing gears, future supervisors and specialists, indirect manufacturing costs, welding, and production control.

Many interesting papers will be given during the tractor sessions. The program for Wednesday, September 13, includes "Safer Design and Use of Farm Equipment" by Martin Ronning, Minneapolis - Moline Co.; "The Self-Propelled Hillside Combine" by D. C. Heitshu, John Deere Harvester Works; "Farm Tractors and Their Tires" by F. C. Walters and W. H. Worthington, John Deere Waterloo Tractor Works, and "Transmissions—Today and Tomorrow," by C. A. Cook, Clark Equipment Company.

R. S. Stevenson, president of Allis-Chalmers Mfg. Co., will be principal speaker at the annual dinner, Wednesday, September 14. The title of his talk is "Engineering—The Measure of our Dynamic Economy".

The Thursday, September 15, program includes the following papers: "The John Deere Model 70 Tractor Diesel Engine" by B. G. Valentine and Russell Candee, John Deere Waterloo Tractor Works; "Effect of Alcohol-Water Injection and Rotation on Tractor Valve Life" by J. A. Weber, University of Illinois; "Mule to Mechanization" by R. W. Wilson, R. H. Bouligny, Inc., and William Splinter, North Carolina State College, and "Developments of Safety Clutches for Power Line Drives", by S. C. Heth, J. I. Case Co.

The annual golf tournament will be held on Friday, September 16.

North Carolina Section Meeting

"KNOW North Carolina and its Engineering Problems" is the theme of the meeting of the ASAE North Carolina Section to be held at the Jefferson Hotel, Morehead City, September 9 to 10.

T. W. Edminster, agricultural engineer, eastern soil and water management section (SWCRB, ARS) U.S. Department of Agriculture, will speak on the topic "Drainage: A Continuing Challenge to Agricultural Engineers". A. D. Swindell, president of the state association of soil conservation district supervisors, Pantego, N. C., will discuss bringing organic soils into production.

The business meeting is scheduled for Friday, September 9, at 3:15 p.m. A field trip to the Open Grounds Farm, owned by Miss Georgina P. Yeatman, is planned for the morning, Saturday, September 10.

President Worthington on North Atlantic Section Program

"LOOKING Ahead with Agricultural Engineering" will be the topic chosen by ASAE President Wayne H. Worthington for his address before the meeting of the North Atlantic Section of the American Society of Agricultural Engineers to be held August 22 to 24 at the University of Connecticut, Storrs.

Other noted speakers on the general program include Herrell DeGraff, school of nutrition, Cornell University, who will speak on agricultural economics, and J. R. Montague, director of engineering, the Hydro-Electric Power Commission of Ontario, who will discuss the engineering features of the St. Lawrence power project.

The second day of the meeting will be devoted to concurrent sessions of the four technical divisions. Many interesting papers appear on the program. Such topics as flood damage, hurricane runoff, tile drainage history, liquid fertilizer application, mist-concentrate sprayer, vegetable harvester, diversion ditches, concrete stave silos, paints for steel roofing, capture and retention of solar heat, poultry brooding and ventilation systems, and many others will be covered during the day-long meetings.

A general program is planned for the final day of the meeting. A movie of the New England Hurricane will be shown and the discussion and papers will be on the general subject of the ravages of wind and water. In the afternoon the general subject will be on restoring damage from wind and water. *(News continued on page 560)*

Michigan State's Centennial of Farm Mechanization

UP TO 500,000 visitors are expected to attend the "Centennial of Farm Mechanization" to be held on the Michigan State University campus, August 15 to 20.

Billed as an outstanding phase of the University's year-long centennial celebration, the agricultural engineering event will go back 100 years and show how the many facets of rural life have changed.

A 20-million-dollar farm machinery display will feature hydraulic-equipped tractors with two-way radios, $11,000 cotton pickers that twist the fiber from the ripened bolls, mechanical peanut harvesters, and a machine that pulls, tops and loads sugar beets.

The first combined harvester-thresher invented in 1836 will be exhibited in the historical machinery display. Horse-drawn plows, wheel cultivators, hay loaders, harrows and seeders will also be shown.

Steam engines will be demonstrated at the "Thresherman's Roundup".

A home-equipment exhibit will trace the development of kitchens from 1855 to the present and show the progress made in sewing machines, vacuum cleaners and flat irons.

A mobile home exhibit will show how home units have advanced over the century. One of its features will be a 100-year old "Romany caravan" from England, a horse-drawn mobile unit, said to be the first in the history of the industry.

Automobiles and trains of yesterday, today and tomorrow will show how transportation has served agriculture.

Atomic energy and a cathode ray machine will reveal science's role in farming.

How oil, rubber and steel have increased farm yields and the part they have played in reducing farm labor, from five man-hours to produce a bushel of corn 100 years ago to about four minutes today, will be told in exhibits.

A miniature town of special buildings including grain, hay and fruit storages, farm shops, dairy barns and silos will be erected for the show.

Among other items to be demonstrated will be tilling the soil 2 ft below the surface, construction of a 100-ft-long drainage ditch in one second, tractor safety and fire fighting on the farm.

A pageant, 1½ hr long, will dramatize the life of a farm family through four generations from the Civil War to the present. The pageant stage will be made up as a typical farm home which will overlook a 16,000-sq-ft area representing farm land. As the years progress the interior of the open farm home will change with the period. The cast will be costumed in the style of each particular era.

The centennial and pageant, held daily and four evenings during the centennial, will be open to the public free of charge.

The farmer of the early 1900's who depended on the gasoline engine (similar to the one shown here) as his chief source of mechanical power, could well have been suspicious of the modern, tiny electric motor which produces many times the horsepower of the older, larger engine. The story of farm mechanization progress during the past 100 years will be unfolded by the more than 600 exhibits of farm and home machinery and equipment at the Michigan State University Centennial of Farm Mechanization to be held August 15 to 20

ASAE MEMBERS in the News

L. R. CLAUSEN

C. E. FRUDDEN

A. B. SKROMME

G. B. NUTT

L. R. Clausen, an ASAE member for about 30 years, has resigned as chairman of the board of J. I. Case Co., Racine, Wis., after serving in that capacity since 1948. He will continue to serve as a director.

Mr. Clausen served as president of J. I. Case Co. for 24 years before becoming chairman of the board. During his presidency, the Case company grew to eight plants, and the abandonment of automobile manufacture in favor of full-line farm machinery production was accomplished.

Mr. Clausen was graduated from the University of Wisconsin as an electrical engineer. His first employment was in the electrical field and later he worked for a railroad. His college education was financed by working on farms primarily.

In 1912, Mr. Clausen joined Deere & Company and rose to the position of vice-president in charge of manufacturing. He also served as a director of the Deere organization. In 1924 he accepted the presidency of the Case company.

•

C. E. Frudden, consulting engineer for the tractor group, Allis-Chalmers Mfg. Co., Milwaukee, and regarded as one of the founders of the tractor industry, retired from active service in July. He has been with Allis-Chalmers since 1929.

Erwin Frudden served as a member of the ASAE Council during a three-year period, 1941-44, and is a past national president of the Society of Automotive Engineers.

During his career with Allis-Chalmers he has been chief engineer at West Allis Works, executive engineer of the tractor group, and consultant for the farm machinery branch of the War Production Board during World War II. Having many inventions in his name for the company, he also was instrumental in the development of rubber tires for farm tractors.

Prior to coming with Allis-Chalmers he was chief engineer in charge of engine design with the Buda Co., Harvey, Ill.

He received his engineering degree from Iowa State College in 1909 and did graduate work at Columbia University. After college he became associated with C. W. Hart, president of a small gasoline engine manufacturing plant at Charles City, Ia. Together they developed a gasoline traction engine, a forerunner of the farm tractor.

In 1950 he received the Iowa State College Marston Medal awarded annually to an engineering graduate of Iowa State in recognition of achievement in engineering and participation in affairs of national engineering societies.

•

Arnold B. Skromme, assistant chief product engineer at the John Deere Ottumwa Works, Ottumwa, Iowa, has been promoted to the position of chief product engineer at the John Deere Spreader Works, East Moline, Illinois.

Mr. Skromme joined the Ottumwa Works in 1950 after serving several years with the Pineapple Research Institute in Hawaii. He graduated in 1941 with an agricultural engineering degree from Iowa State College and received the ASAE honor student award. After graduation he became tire and track development engineer for the Firestone Tire & Rubber Co., Akron, Ohio, and in 1945 he joined the Auto Specialties Mfg. Co., at St. Joseph, Mich., as field engineer.

▪

John C. Campbell has resigned as extension agricultural engineer, University of Illinois, to engage in a private business enterprise at Corvallis, Ore.

Geo. B. Nutt, head, agricultural engineering department, Clemson Agricultural College, Clemson, S. C., was named director of the Clemson Agricultural Extension Service on July 18.

Mr. Nutt, who served in 1954-55 as president of the American Society of Agricultural Engineers, is a native of Mississippi. He graduated from Mississippi State College in 1930 and joined the Clemson staff in 1932 as an associate professor of agricultural engineering. He received his M.S. degree from Iowa State College in 1940 and was made a full professor and head of the Clemson agricultural engineering department the next year.

▪

Paul W. Stoneburner, who the past few years has been employed as sales engineer of Atlantic Aluminum Company, distributors and fabricators of aluminum products, Waynesboro, Va., was recently promoted to the position of general manager of the company.

•

A Correction

In this column in the June issue of AGRICULTURAL ENGINEERING, it was erroneously stated that Merle H. Peterson had been promoted to chief engineer of the tillage division at the Racine, Wis., Works of Massey-Harris, Ferguson, Inc. The following will straighten out the confusion of names responsible for the error:

Merton W. Peterson, formerly a project engineer, was earlier this year made assistant chief engineer of the tillage division at the Racine works of Massey-Harris-Ferguson, Inc., and was promoted again in May to chief engineer of the tillage division.

Merle H. Peterson earlier this year resigned an engineering position with the Bolens Products Division of Food Machinery and Chemical Corporation to accept employment as a project engineer with Massey-Harris-Ferguson, Inc., at Racine.

John R. Carreker, agricultural engineer, Eastern Soil and Water Management Section (SWCRB, ARS), U.S. Department of Agriculture, on July 1 assumed administrative responsibility for the Southern Piedmont Conservation Research Station at Watkinsville, Ga. In this position he will also administer the three pilot research farms attached to the Station.

•

Charles D. Busch recently joined the group of research workers of the Eastern Soil and Water Management Section (SWCRB, ARS, USDA) located on the campus of Cornell University at Ithaca, N. Y., where, in collaboration with the Cornell agricultural engineering department, he will have two major responsibilities: assist in the development of improved tillage practices for erosion control and elimination of unnecessary tillage operations, and develop improved interception drainage systems utilizing new materials such as plastic tubing, bituminous fiber pipe, etc. Mr. Busch is a native of New York and received his B.S. in agricultural engineering from Cornell in 1951. After two years of military service in the research branch of the U.S. Army, he completed requirements for an M.S. degree in agricultural engineering at the Utah State Agricultural College in June.

▪

L. Donald Meyer has been appointed agricultural engineer on the newly established project of the Eastern Soil and Water Management Section (SWCRB, ARS, USDA) at Lafayette, Ind. He will be engaged in developing equipment and methods of measuring and evaluating the comparative effectiveness of various tillage and erosion control practices through the use of simulated storm techniques. Particular emphasis will be placed on broadening the area of application of the erosion index developed by Browning *et al.* Mr. Meyer is a native of Missouri; he received his B.S. in agricultural engineering in 1954 from the University of Missouri and his M.S. degree in 1955.

▪

Thomas C. Shirley, until recently a field representative of Dixie Irrigation Co., Nashville, Tenn., has been added to the staff of the Tennessee Association of Rural Electric Coops, in which position he will assist with the promotion of power-use among the state associations member coops and coordinate the work of coop power-use personnel with that of commercial and educational groups and those interested in farm production.

During World War II, Mr. Shirley served in the U.S. Navy in radar operation and maintenance. On leaving the service, he enrolled in the professional agricultural engineering curriculum at Mississippi State College and received his B.S. degree in that subject in 1949. Following graduation, Mr. Shirley served with the Tennessee Valley Authority for a time as an electrical development representative, where he worked with power-use staffs of TVA-served coops in promoting increased use of electricity on the farm.

▪

Arnold Nicholson, who for several years has been on the editorial staff of *Country Gentlemen*, and during the past few years as managing editor, has recently been made an associate editor of *Saturday Evening Post*.

•

William E. Knapp, until recently chief engineer at the Moline, Ill., works of Minneapolis-Moline Company, will for the next two years be chief engineer of Minneapolis-Moline Turk Traktor ve Ziraat, at Ankara, Turkey.

Eugene P. Speck, until recently agricultural engineer and sales promotion manager of the Treanor Equipment Company, Delano, Calif., is now assistant director of field stations and associate specialist in the agricultural experiment station of the University of California and is stationed at Davis.

•

Edward H. Busch, formerly cotton ginning specialist, agricultural extension service, A. & M. College of Texas, is now executive vice-president of the Texas Cotton Ginners Association, publishers of the *Cotton Ginners Journal* and the *Ginners Redbook*.

•

J. D. Rector recently resigned his position as junior engineer at the David Bradley Mfg. Works, Bradley, Ill., to accept a position as product and irrigation engineer with Doerr Metal Products, Larned, Kans.

•

Guy O. Woodward has resigned as extension irrigation specialist at the University of Wyoming to accept appointment to the newly created position of educational director of the Sprinkler Irrigation Association. In this position, Mr. Woodward will be responsible for the establishment of irrigation clinics to be jointly sponsored by the SIA, the federal extension service, and the agricultural colleges. He will also be responsible for future revisions of the SIA handbook on sprinkler irrigation.

Mr. Woodward is a graduate of Utah State Agricultural College where he majored in irrigation and soils. Following graduation he was employed for four years by the Holly Sugar Corp., Delta, Colo., where he was responsible for engineering on the company's irrigation projects. The following four years he managed his own farm and at the same time served as a county engineer in Idaho. He is presently chairman of the ASAE Rocky Mountain Section.

For the time being, Mr. Woodward will maintain business headquarters at his home at 1924 Grand Ave., Laramie, Wyo.

•

Volney H. Smith, who has been employed by the U.S. Soil Conservation Service, at Shenandoah, Iowa, was transferred recently to the area engineer's office at Council Bluffs, where he is acting in the capacity of assistant area (agricultural) engineer.

•

Herman S. Poorbaugh has resigned as general manager of the Quarry Castings and Supply Division, Donegal Mfg. Corp., to establish his own supply business, specializing in wear-resistant castings and welding electrodes, at York, Pa.

•

Thomas Evans, who has been serving as chief engineer at the Louisville (Ky.) Works of Minneapolis-Moline Co., has been transferred to the main works at Minneapolis where he has been made chief engineer of the company's farm machinery division. Mr. Evans, together with Ben G. Van Zee, chief engineer of the automotive division, will jointly handle the research and development work of the company's engineering department.

•

James Turnbull has resigned as state conservation engineer of the U.S. Soil Conservation in Maryland and Delaware to accept appointment to the technical staff of the state experiment stations division, Office of Experiment Stations (ARS), U.S. Department of Agriculture. He is designated as agricultural administrator in the subject-matter field of agricultural engineering. Prior to his present assignment, Mr. Turnbull was regional drainage engineer with the Bureau of Reclamation, U.S. Department of the Interior, at Billings, Mont. During his connection with the SCS research group, he also conducted irrigation and drainage research in Louisiana, Florida, Georgia, and Maryland. During World War II Mr. Turnbull served for a period as a commissioned officer in the U.S. Public Health Service.

•

Donald R. Longabach recently resigned as project engineer in the Tractor & Implement Division, Ford Motor Company, to accept a position of research engineer in connection with the testing and development of new machines at the Caterpillar Tractor Co., Peoria, Ill.

•

Reuben J. Aho, who has been employed as product test engineer at the East Moline, Ill., works of International Harvester Co., recently resigned to accept a position as experimental engineer with The Oliver Corp., South Bend, Ind.

•

Emmett R. Holekamp has resigned as assistant professor of agricultural engineering at the University of Arizona to accept appointment as associate agricultural engineering technologist on the agricultural engineering department staff at the University of Idaho, Moscow. He will be engaged in research in farm mechanization.

•

R. Bruce Hopkins who has been a graduate assistant in the agricultural engineering department of Michigan State College, has taken an engineering position at the John Deere Waterloo Tractor Works, Waterloo, Iowa.

•

James Landreth, until recently employed as agricultural engineer of the Tea Research Institute of Ceylon, recently resigned to accept employment with the Repco Automotive Bearing Manufacturing Co. Mowbray, Launceston, Tasmania.

•

Yoram Gordon, who has been employed as a hydraulic engineer in the flood control section of the Corps of Engineers, U.S. Army, is taking an assignment in Israel and will be located at 18 Gaza Road, Rehavia, Jerusalem, Israel.

George B. Nutt *(right)*, retiring president, is about to present the gavel to the new Society president, Wayne H. Worthington at the annual dinner of the American Society of Agricultural Engineers held June 14 in the Illini Union at the University of Illinois. Mr. Worthington is director of engineering research at John Deere Waterloo Tractor Works

G. W. Steinbruegge has resigned as professor of agricultural engineering at the University of Arkansas, to accept a position on the agricultural engineering staff of the University of Nebraska.

•

Leonard A. Brandrup, for several years agricultural engineer at Seabrook Farms, Bridgeton, N. J., is now employed as an experimental engineer in field testing for The Oliver Corp., Charles City, Iowa.

•

Merle L. Esmay recently resigned as professor of agricultural engineering at the University of Missouri to accept a position on the agricultural engineering staff of Michigan State University, East Lansing.

•

W. L. Denniston has resigned as sales engineer of the Berry Division, Oliver Iron and Steel Corp., to accept a sales engineering position with the newly organized hydraulic drives department of Westinghouse Electric Corporation at Muncie, Ind.

Research Projects in Agricultural Engineering

[EDITOR'S NOTE: This list of active research projects supplements the list published in the June issue of AGRICULTURAL ENGINEERING.]

University of California, Davis

Rural Home Design for the Warm, Interior Valleys of California, No. 396H

Farm Fences: Wood Post Durability, No. 3961(A)

Farm Fencing: A Twenty-Year Atmospheric Test of Wire and Wire Fencing, No. 3961(B)

Rural Sanitation, No. 396J

A Study of Poultry Housing, No. 396K

Miscellaneous Tests of Tractors and Farm Machinery, No. 400D

Relation of Electricity to Agriculture, No. 400N

A Study of the Efficiency of Orchard Heating, No. 400U

Experiments in the Operation of Dairy Machinery and Equipment, No. 701

Barns and Equipment for Livestock in California: Part I—Swine; Part II—Sheep; Part III—Beef Cattle; Part IV—Dairy Cattle, No. 861

Engineering Applications to the Production and Handling of Vegetable Crops, No. 947

Heat Transfer in Dairy Machinery, No. 1043

A Study of the Basic Requirements and Design Principles of Mechanical Equipment for Pest Control, No. 1046

Economic and Engineering Studies of Packing House Practices (R & M federal project), No. 1331

Relation of Animal Productivity to Modified Local Climatic Environment (Coop USDA), No. 1358

Cotton Mechanization (Coop USDA), No. 1361

Use of Aircraft in Agriculture, No. 1423

Criteria for Poultry House Design, No. 1467

Forage Seed Harvesting and Processing, No. 1549

Mechanical Harvesting and Deciduous Tree Fruits and Nuts, Grapes, Olives and Berries, No. 1551

Engineering, Qualitative and Economic Studies of the Packaging, Handling and Shipping of Deciduous Fruit, No. 1579

(1) Drying (rice, hops, corn, etc.)

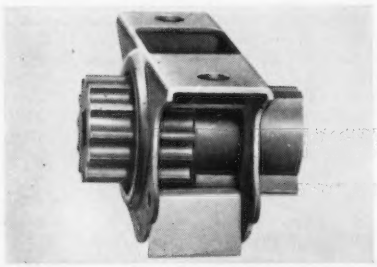
(2) Weather Climatology (Misc.)

A report to you about men and machines that help maintain International Harvester leadership

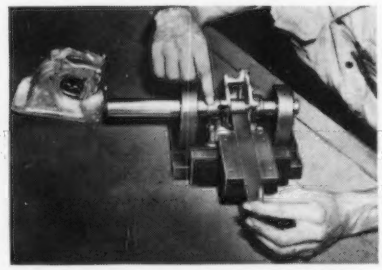
How IH Manufacturing Control safeguards the accuracy and long life of McCORMICK® GRAIN DRILLS

Maintenance of rigid quality control is a continuing, *three-way* operation in the manufacture of McCormick grain drills. *First:* all parts are precision built to exacting specifications from top quality material. *Second:* all parts are assembled carefully on modern factory production lines. *Third:* rigid inspections during every step of manufacture safeguard accuracy, dependable field performance, and long life. Here are seven examples of this quality control in manufacture—examples that result in *product quality* and *customer satisfaction*.

More than 700 factory tests help safeguard the dependable field performance of McCormick grain drills. In this test, fluted feeds are inspected for uniform, accurate seeding.



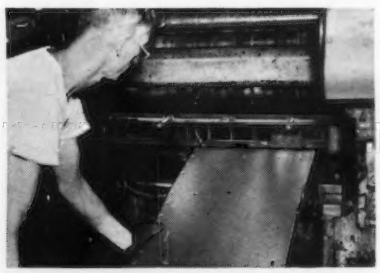
New materials, like powdered metal used in the roll of this feed cup assembly, get thorough testing, are adopted if they meet manufacturing standards. Result: more uniform, precise seed distribution.



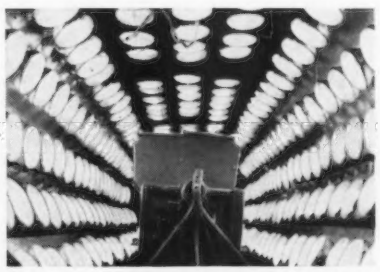
Every fluted feed assembly must pass 14 different gauging tests. Feed cup, fluted roll, shut-off block, and dump bottom are individually checked for uniformity. Every assembly must be alike.

Checking the concavity of single-disc blades calls for close inspection. Concavity is held within .015-inch limits to assure true-trailing in the soil. Each disc blade is individually checked.

Single-disc openers are gauged in assembly for alignment. Identical undercut and angle of draw are built into each assembly, to assure uniform penetration.



One-stroke punching of drill hopper holes with this machine keeps all holes in perfect alignment. The result is a more economical and durable assembly.



After a two-coat spray painting, this battery of 390 infra-red lamps bakes the finish on drill hoppers, makes the surface hard, durable, corrosion-resistant.

High quality standards of McCormick grain drills are the result of teamwork between IH research, engineering and manufacturing men. This team constantly pools its time and talent to provide equipment of improved performance and durability—to help farmers boost production while keeping costs at the minimum.

INTERNATIONAL HARVESTER

International Harvester products pay for themselves in use—McCormick Farm Equipment and Farmall Tractors . . . Motor Trucks . . . Crawler Tractors and Power Units . . Refrigerators and Freezers—General Office, Chicago 1, Illinois.

NEW PRODUCTS CATALOGS

Plate-Type Strip Cup

Babson Bros. Co., 2843 W. 19th St., Chicago 23, Ill., has developed a new plate-type strip cup designed to detect early symptoms of mastitis.

The new strip cup has a wide, flat, dark-colored surface, with concentric rings like a phonograph record, which show up small flakes of mastitis before the usual "ropiness" appears. Dairymen find that the new plate cup is easy to clean.

Hydraulic Nut Harvester

The Hydreco Division, The New York Air Brake Co., 1107 E. 222nd St., Cleveland 17, Ohio, has developed the hydraulic system used in a new nut harvester being manufactured by Gould Bros., San Jose, Calif.

The new harvester, called the hydraulic "giraffe", consists of a long boom that can be mounted on utility-type wheel tractors. A padded clamp on the upper end of the boom

is said to grip the limb firmly without bruising the bark, yet gives the tree a thorough shaking that jars loose all the ripe nuts.

A hydraulic pump supplies pressure which is applied through a two-plunger control valve. To elevate the boom and position the clamping device the operator pulls a plunger, which directs the oil to the main thrust cylinders. Then he pulls the second plunger for applying pressure to the jaws through the clamping cylinder. After the boom is clamped and pressure is built up, the oil by-passes through a sequence valve to the motor which drives an eccentric for shaking.

Fencing Booklets

United States Steel Corp., 525 William Penn Place, Pittsburgh 30, Pa., will send on request to interested readers three pieces of literature that are designed to help farmers and ranchers with fencing problems.

The first folder, "Fence Planning Saves," explains in detail how to plan a fencing program and is designed to be used before a fence is installed. A handy tracing grid is included for making a drawing of fields to be fenced.

The second booklet, "Fences That Pay," tells how to erect each specific fence. A drawing of a constructed fence having nearly every fencing problem shows proper installation, and accompanying instructions explain how to handle topographic and soil problems.

The third booklet is an animated, color story of T. T. Termite and his experiences with pressure-cresoted wood, entitled "A Boring Tale."

Triple Spray Head

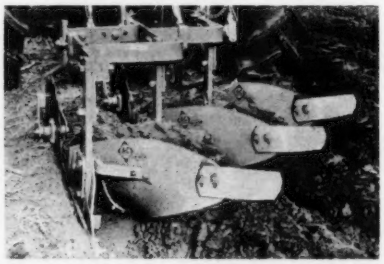
Spraying Systems Co., 3226 Randolph St., Bellwood, Ill., has designed its No. 6115 triple spray head for use with ¼U VeeJet nozzles to improve the effectiveness of tree spraying with low-gallonage sprays. Small

capacity nozzles with narrow spray angles ranging from 15 to 25 degrees mounted in the triple spray head provide a well-atomized spray. The spray head is made with a ½-in inlet pipe connection for mounting to ½-in extension pipe. The head is available in either brass or aluminum.

New Plow Design

Allis-Chalmers Mfg. Co., Tractor Division, Milwaukee 1, Wis., has introduced a new plow bottom design, from frog to share point, identified as the Bullet Blade bottom.

A reduced shearing angle is said to provide good soil piercing. The blade is placed at a 36-degree angle to the landside. The furrow slice is lifted gradually—3½ inches



in the first 10 inches of forward travel. Crumbling of the furrow slice is reportedly low as it passes over the blade.

The flat blade surfaces are designed to give uniform down pressure and uniform wear the full length of the blade instead of concentrating wear on the point. The shin piece is replaceable. Adjustable moldboard extensions are standard equipment. The frog is a two-piece welded type. A bond-welded layer of long-wearing material has been added towards the rear lower corner of the landside.

Included in the group of four new bottoms is a new slat bottom.

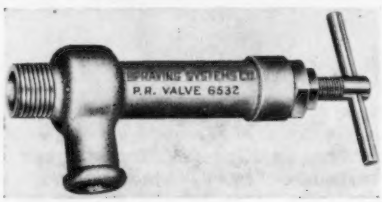
Drive-In Cultivator

J. I. Case Co., Racine, Wis., has announced its new 4-row drive-in cultivator which can be mounted on the tractor in a matter of minutes. The tractor is driven into the cultivator while the front-hinged gangs are in the outward position. After the front beam is secured, the hinged gangs are swung inward to the tractor and fastened with two

bolts. To demount, hinged-front gangs are swung out away from the tractor, where special stands support the beams in storage position. Adjustment provides for either 28, 36, 38, 40 or 42-inch row spacing. The entire cultivator has a high, parallel lift for easy turning and it is rigidly mounted for fast dodging and has high clearance for late-season crop work. One hydraulic control handles both front and rear gangs for raising or lowering.

Pressure Relief Valve

Spraying Systems Co., 3226 Randolph St., Bellwood, Ill., announces its new No. 6532 pressure relief valve which makes it possible to vary line pressures to spray booms to meet the requirements of different kinds of chemicals. Installed in the line and after the pump and before the boom, this valve permits varying of pressure to the boom at



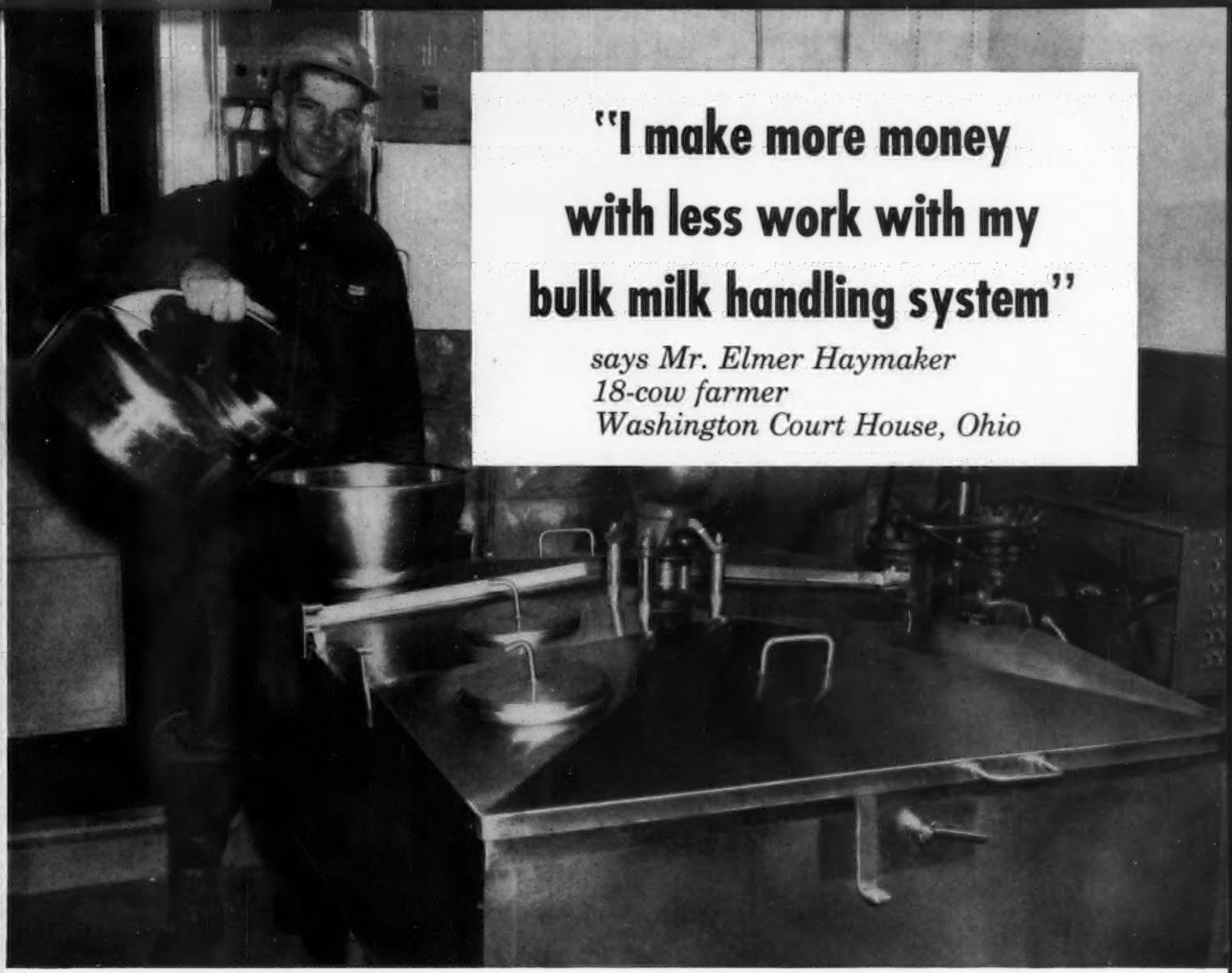
any level from 10 to 300 psi by controlling the by-pass flow. It will also provide full by-pass flow when the spray boom is shut off thereby minimizing pressure buildup. It will adjust automatically to normal variations in boom pressure due to differences in tractor speeds. The valve is made of aluminum with dual stainless steel springs and stem. The dual spring construction makes possible closer valve control at lower pressures.

New Digger-Mulcher

J. I. Case Co., Racine, Wis., announces a new digger-mulcher designed to perform both light and heavy-duty tillage operations; it is available with either 6 or 12-in spacing

for tool standards. It is designed to handle a wide variety of jobs from light quack grass eradication to tough spiking and chiseling.

(Continued on page 544)



"I make more money with less work with my bulk milk handling system"

says Mr. Elmer Haymaker
18-cow farmer
Washington Court House, Ohio

"I'll never go back to the old way," says Mr. Haymaker, standing beside his 150-gallon Stainless Steel bulk milk tank.

And here's why! Mr. Haymaker gets a $.10 cwt. premium for his bulk milk. He saves $.05 on hauling costs. He is getting paid for *more milk* because stickage has been eliminated, and his butter fat count is up by two points. He gets a bigger milk check.

The dense surface of Stainless Steel maintains its polished sanitary finish, making the tank simple to clean. Also, Stainless Steel is one of the strongest metals you can buy; so it will serve you well for many, many years.

Mr. Haymaker figures that he can keep his tank 70% full with his 18 Holsteins. At that rate, the savings will pay for the tank in only 4½ to 5 years. In the meantime, the job of milk handling is much easier.

Stainless Steel tanks are a vital part of the bulk milk system, and USS Stainless Steel is widely used for the purpose. Working with leading manufacturers, United States Steel has learned a lot about bulk milk handling, and we have put this knowledge into a booklet that is yours for the asking. Send coupon.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS • STRIP • PLATES
BARS • BILLETS
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SPECIAL SECTIONS

Agricultural Extension
United States Steel Corporation, Room 4825
525 William Penn Place, Pittsburgh 30, Pa.

Please send me the free booklet on bulk milk handling equipment.

Name .....

Town ..... RFD .....

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Oil Power Helps Manpower
Guide Horsepower with
EASE!

Arm-weary tractor operators are grateful for TD-14A and TD-18A International Harvester crawlers. They steer with the ease of a late model car for each track is controlled by its own hydraulic circuit...a booster system with velvet smooth, positive action that stems from

HYDRECO
Oil Power

Here is a HYDRECO dual pump that delivers 5 gpm to each circuit at 1200 rpm against a system pressure of 700 psi. The dual pump provides a circuit for each track and the result . . . no arm-weary operators . . . more accomplished with less effort, in less time . . . smoother, higher performance . . . lower maintenance.

For engineers seeking practical answers to problems of trouble-free hydraulic controls, better performance, added functions and greater sales appeal for mobile equipment, the experience of HYDRECO engineers offers a definite answer!

WRITE— *for latest literature and full information on new developments in HYDRECO Pumps, Motors, Valves, and Cylinders.*

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1107 EAST 222nd STREET • CLEVELAND 17 • OHIO
INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

New Products and Catalogs

(Continued from page 542)

Besides functional design features, this digger-mulcher has extra height for ample trash clearance. Construction features include roller-bearing wheels for easy highway transport.

New Wire-Tie Baler

New Holland Machine Co., New Holland, Pa., has announced its new Model 87 automatic wire-tie pickup baler designed to put up 60 to 125-lb bales.

An improved twister and an in-line wire twist are said to make it possible for the new baler to "bear-hug" more hay into each bale. The company reports that the

new baler has a capacity up to 12 tons per hour.

The "87" features fast plunger action and a short closed-bottom wadboard. Sealed bearings are used at friction points.

New Tiller-Packer

J. I. Case Co., Racine, Wis., announces a new tiller-packer, in 8 or 10-ft size which is adaptable to a wide range of operations; it can be used in any of the six following hookups: Single packer using front section, double packer using front and rear sections, spring-tooth section separately, front packer section and spring-tooth section, and all

units—packer, spring tooth, and rear packer.

The front packer rollers are 15 inches in diameter, the rear rollers 12 inches in diameter. The rear rollers can be equipped with special adjustable scrapers as extra equipment, and can be ordered in the 15-in diameter size.

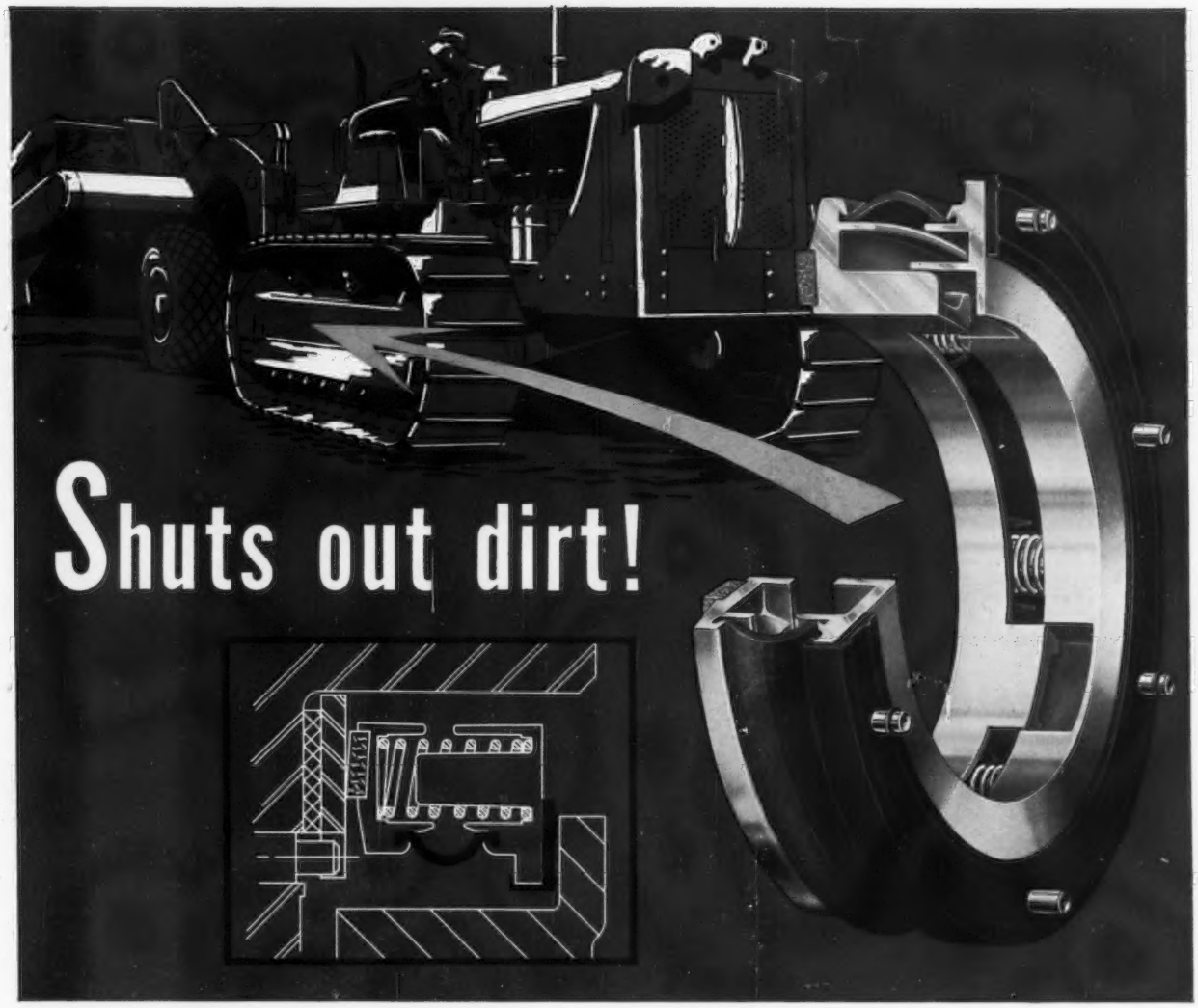
Packer gangs are mounted on light-draft, self-aligning sealed ball bearings. Transport wheels are provided as special equipment.

Drill-Type Corn Planter

The Oliver Corp., 400 W. Madison St., Chicago 6, Ill., announces it has introduced

a new series of drill-type corn planters adjustable to row spacings from 28 to 44 inches. The planter series has been built to

(Continued on page 546)



SAVES DOWNTIME ON BIG CAT MACHINES

Without effective seals, mud and dust would grind the life out of this D6 tractor's final drive—fast. But it's got life-saving C/R Type VD End Face Seals. They keep dirt and water out, seal transmission oil in under considerable end-play and at shaft speeds from 15 to 100 rpm. They're self-adjusting, self-aligning . . . never need take-up or attention. Proved by hundreds of thousands of field hours, these rugged C/R Oil Seals are giving longer service life to the D6 . . . saving big dollars in repairs. C/R's unequalled engineering and production facilities are at your service, too. Write for your copy of "C/R End Face Seals."

C/R

PERFECT Oil Seals

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device

CHICAGO RAWHIDE MANUFACTURING COMPANY

1301 Elston Avenue OIL SEAL DIVISION Chicago 22, Illinois

IN CANADA: MANUFACTURED AND DISTRIBUTED BY SUPER OIL SEAL MFG. CO., LTD., HAMILTON, ONTARIO

EXPORT SALES: GEON INTERNATIONAL CORP., GREAT NECK, NEW YORK

Other **C/R** *products*

SIRVENE: (Synthetic rubber) diaphragms, boots, gaskets and similar parts for critical operating conditions • CONPOR: Controlled porosity mechanical leather packings and other sealing products • SIRVIS: Mechanical leather boots, gaskets, packings and related products.

UNITCASTINGS
PLAY AN IMPORTANT PART IN MANUFACTURER'S LEADERSHIP..

Accuracy cuts cost.
Less than 1 hour machining time is required per unit assembly with Unitcastings.

Accuracy.. Appearance.. and Dependability

..ADD UP TO TOP QUALITY PRODUCT!

A nationally known manufacturer of house trailer tow-bar mechanisms keeps quality up and costs down by specifying *Unitcastings*. Dimensional accuracy, internal soundness and good surface appearance hold finishing costs to a minimum and help retain customer acceptance. In less than six years of production and over 202,000 parts later, less than ½ of 1% of the total castings shipped have been returned for any reason.

Beginning with the original design of the castings, Unitcast's engineering service has kept pace too, by continually modernizing the design to suit automobile chassis improvements. This is just one of the many Unitcast Foundry Engineering Services available to our customers.

Let Unitcast help you modernize your product by including foundry standards in the design. Keep your production cost competitive. . .write today!

UNITCAST CORPORATION • Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

QUALITY STEEL CASTINGS

New Products and Catalogs

(Continued from page 544)

fill the needs of modern, high-speed farming. Besides adjustable row width, it features a choice of two-level fertilizer placement, positive-timed seed and fertilizer feeders with direct roller-chain drives from both ground wheels, additional seeding rates making available 36 different spacings in the row, marker selector on same level that controls planter lift, 80-lb fertilizer hoppers and half-bushel size seed cans, divided fertilizer boots, and constant-running seed plates.

New Diesel Tractor

Allis-Chalmers Mfg. Co., Tractor Div., Milwaukee 1, Wis., is introducing another tractor in its WD-45 family, with its own full diesel, 6-cylinder, valve-in-head engine. The engine has a $3\frac{7}{16}$-in bore and $4\frac{1}{2}$-stroke and 230-cu-in displacement. The

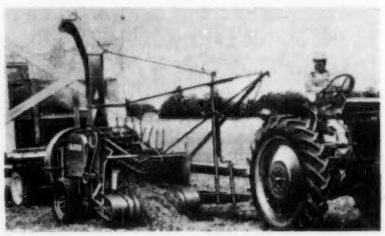
compression ratio is 15.5 to 1 and the rated governed engine speed is 1625 rpm.

Basic design features of this model are power-shift rear wheels which are moved in or out by engine power to the tread selected; snap-coupler hitch which permits quick change from one implement to another, with a single hitch point; complete hydraulic system with automatic traction booster, and two-clutch power control.

New Three-Front Harvester

The Oliver Corp., 400 W. Madison St., Chicago 6, Ill., has announced its new all-season No. 200 forage harvester with three quick-change fronts. A five-foot cutter bar unit is used for standing hay crops, a pick-up unit for chopping cured hay in the windrow and a row-crop attachment for harvesting corn and similar row crops.

All three units are mounted on dolly wheels, enabling the attachment to be de-



tached and rolled away from the basic machine. The change-over to another front takes only a few minutes.

This new harvester is the cylinder type. The chopping and elevating units are separate and operate at different speeds. The feed rolls are reversible from the tractor seat. Another control adjusts the discharge pipe to compensate for side winds and to direct the deflector for even loading of the wagon.

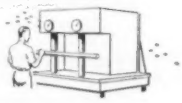
The square shear bar can be rotated to a new cutting edge when one becomes dull. An attachment for sharpening the knives without removing them from the machine is available.

For top auger performance

LINK-BELT gives you these 5 engineering and manufacturing extras

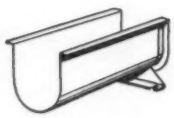
1 STEELS MEET RIGID SPECIFICATIONS

Only selected steels are used—assuring a uniform, smooth, accurately rolled product.



2 ALL COMPONENTS AVAILABLE FOR "TAILORING" TO YOUR MACHINE

Every component can be supplied by Link-Belt, specially engineered for your requirements. This includes troughs, spouts, hangers, screws and drives.



3 CONTROLLED UNIFORMITY OF PITCH

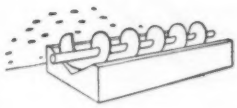
Specialized, modern machinery assures accurate forming to produce uniform flighting.

4 ONE-PIECE, CONTINUOUS FLIGHTING

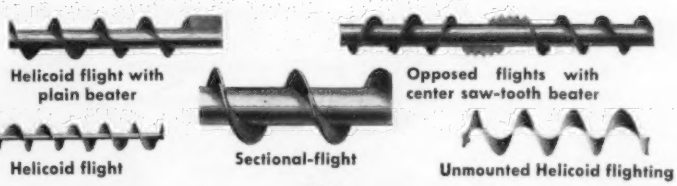
One-piece HELICOID flighting has greater smoothness and strength. Link-Belt also builds many different types to meet your special needs—cut flight, short pitch, ribbon flight, double flight to name a few.

5 STRAIGHTNESS

Straightness of completed auger is carefully checked before shipping assemblies. Then extra care is taken in handling and loading.



Typical LINK-BELT augers

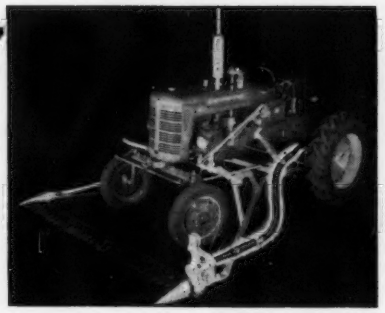


This 92-page Data Book No. 2289 contains complete information. Ask your nearest Link-Belt office for a copy.

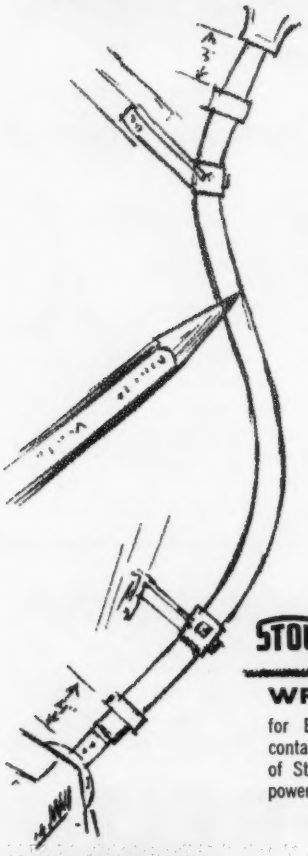
LINK-BELT

FARM MACHINE AUGERS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. 19,801



picture of a
design engineer
who **had** a
power transmission problem



Know who this fellow is?

We'll tell you*, but first, here are the facts about the power transmission problem he licked with STOW flexible shafting.

Briefly, this company had the problem of supplying power to a mower on a farm tractor, from the tractor's power take-off which was 7 feet away. Raising and lowering the mower further complicated the problem because of the relative motion introduced between the ends of the shaft. Further, the drive used had to be dependable, economical, easy to maintain and safe.

*This Krengle's Inc. engineer found the answer in STOW flexible shafting. 1-inch shafting, with specially designed end terminals, was used for this job.

STOW your problems—

WRITE TODAY

for Engineering Bulletin 525 containing detailed information of Stow Flexible Shafting for power drives and remote control.

STOW

MANUFACTURING CO.

Originators of the Flexible Shaft

39 Shear St., Binghamton, N. Y.

RESEARCH NOTES

Brief news notes and reports on research activities of special agricultural-engineering interest are invited for publication under this heading. These may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Michigan.

USDA Research Activities

Light Traps in Texas. Five farmers, growing cotton, corn and vegetable crops on 3,300 acres of land near Batesville, Tex., have installed 156 electric grid light traps as a means of insect control on their farms this year.

This is the largest single installation made thus far of the traps, the basic attractant of which was established by USDA engineers of the Farm Electrification Section, Agricultural Engineering Research Branch. The traps now in use on the Texas farms combine the "black light" as an insect attractant, and a grid to kill the insects trapped.

The installations this year represent expansion of use of similar traps by one Batesville farmer on 800 acres of cropland during the past two years. The traps have been found effective in experimental and commercial use as a means of detecting the presence of many crop-destroying insects, including the pink bollworm in some areas in which they were not previously known to exist.

Because this is the first time the light traps have been given a large-scale tryout as a means of direct control, the project is being closely observed by USDA engineers and entomologists. Agricultural engineers, J. P. Hollingsworth and Lyle M. Carter, of the Farm Electrification Section, located at College Station and Brownsville, Tex., are keeping check on the light traps to determine their efficiency and as a possible means of future improvements.

Some weather-station equipment, such as a rain gage and an anemometer, is being used in connection with the light-trap equipment to study variations in insect-trapping efficiency that might be linked with changing weather conditions.

Farm Silo Studies. The AERB's Farm Buildings Section is expanding its study project of farm silos, with plans to set up the work at a field station, probably in Georgia as soon as possible. A field project for the Great Plains area is being contemplated for the future.

Engineering phases of the work in progress on the project at the USDA Agricultural Research Center at Beltsville, Md., is in charge of J. R. McCalmont and Lowell E. Campbell.

Present efforts are concerned primarily with studies of the over-all efficiency of two experimental horizontal silos at Beltsville. Comparisons are being made to determine relative losses of silage as between the horizontal and upright types. However, the objective is to find whether the lower-cost-lower-labor horizontal silos pay off in comparison with the higher-cost-lower-feed-loss upright types.

Incidental to this objective will be the study of different types of covering materials for the horizontal silos based on cost of the covers, cost of application, lasting qualities, and ability to prevent or cut down top spoilage of the silage normally running fairly high in horizontal silos.

FOR REMOTE CONTROL JOBS on a great variety of AGRICULTURAL EQUIPMENT

TRU-LAY *Flexible* PUSH-PULLS

are Dependable and Accurate even under the most adverse conditions. They perform effectively under extremes of Heat or Cold . . . from jet engine temperatures to 70° below F. The inner, working member (lubricated for life during assembly) is fully protected by the tough, flexible conduit. Abrasive dusts, dirt and moisture are sealed out. Fittings are cold swaged to make them integral parts of the control unit. It is a matter of record that we have never heard of a TRU-LAY *flexible* PUSH-PULL wearing out in normal service. Use of these versatile, simple and rugged controls means the virtual Elimination of Maintenance.

Widely Used on Agricultural Equipment

Adaptability to all sorts of mechanical situations explains, in large measure, the wide-spread use of TRU-LAY PUSH-PULLS on Tractors and their accessories, Combines, Corn Pickers, Corn Detassler Machines, Corn Row Sprayers, Orchard Sprayers, Tobacco Picking Machines, Power-driven Tree Trimmers and others.

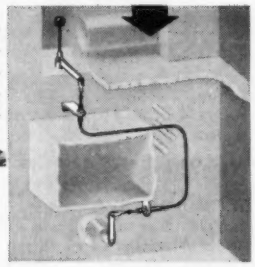
On Agricultural Equipment these dependable Push-Pulls are used for the remote control of Transmissions, Hydraulic and Air Valves, Brakes, Clutches, Throttles, Chokes, Governors, Power Take-Offs, Spray Nozzles, Vent Directional Fins, etc.

TRU-LAY PUSH-PULLS are precision products, not gadgets. They provide positive remote-action whether anchorages are fixed or movable . . . for light loads or loads up to 1,000 lbs. . . . and they are effective over short or long distances, up to 150 feet or more.

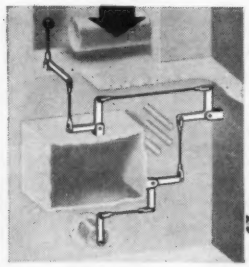
***Advantages** of Tru-Lay Push-Pull flexibility and simplicity are pictured below*

TRU-LAY PUSH-PULL

Simple
One Moving Part
Life-Time Service
Life-Time Accuracy
Low over-all Cost
Noiseless



MECHANICAL LINKAGES



Complex
Many Parts
Many Points of Wear
Increasing Back-Lash
Loss of Accuracy
Vibration
Rattles

"Solid as a rod but *Flexible* as a wire rope" is a good description of TRU-LAY PUSH-PULL REMOTE CONTROLS. This flexibility makes it possible to snake around obstructions as shown in the picture at the left . . . permits the ideal arrangement of all control elements . . . greatly simplifies installation of controls by reducing the number of working parts . . . damps out noise and vibration. Versatile, Accurate, Adaptable, Rugged . . . they are the ideal Remote Controls for Agricultural Equipment.

Our DATA FILE will answer your further questions
Write for a copy without obligation

ACCO

AUTOMOTIVE and AIRCRAFT DIVISION
AMERICAN CHAIN & CABLE

TRADE MARK

601-B Stephenson Bldg., Detroit 2
2216-B S. Garfield Ave., Los Angeles 22 • 929-B Connecticut Ave., Bridgeport 2, Conn.

Users Report Important Savings, Improved Design and Better Appearance with TRU-LAY Push-Pulls

Here are typical benefits reported by users of these accurate and dependable Remote Controls.

Governor

"For several models of farm tractors, we selected your controls for their simplicity and neatness of application as governor controls."

Transmissions—Clutches—Brakes

"Greater flexibility of design. For remote control of transmissions, clutches and brakes these Flexible Push-Pulls can be installed where straight rods are impossible."

Power Take-Off—Brake—Clutch

"Easier and less expensive to install than linkages for remote control of power take-off, brake and clutch. Better appearance, too."

Hydraulic Control Valve

"The principal advantage in the use of the Tru-Lay cables in our application is that of permitting a more flexible location of the control valve in relation to the operator's position."

Engines—Conveyors

"The use of your Flexible Push-Pulls saves us a great deal of time, labor and material. The old linkages frequently required much planning in both engineering and shop which is not required now. On some of our equipment we use Push-Pulls from 10 to 30 feet in length. They operate clutch controls on the Main Power Unit, Feed Conveyors and Delivery Conveyors."

Wide Range of Application

Adaptability to all sorts of mechanical situations explains, in large measure, the widespread application of TRU-LAY PUSH-PULLS. Standard anchorages, fittings and heads have been designed that meet requirements on approximately 80% of the installations. Simple modifications of these standards, or minor changes in your own design, cover almost every special situation. Our engineers have the know-how on such matters. See our catalog in Sweet's Design File, write us for the DATA FILE described at the left, or ask to have a sales engineer call.

See the latest developments in Safety Controls in our exhibit at Centennial of Farm Mechanization Michigan State College August 15th-20th

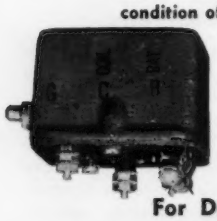
working in the field or powering your irrigation pumps

Prevent down time and overhaul expense due to engine damage caused by failure of lubrication or cooling system failure. Adaptable to all types of ignition systems: Magneto, Battery and Diesel.

For Magneto Ignition Tractors and Engines
WR-275 Panel (Basic Instrument)

MURPHY Model WR-275 offers complete engine protection for magneto ignition tractors. An oil pressure switch-gauge and water temperature switch-gauge in streamlined, cast tenzaloy panel.

Mounts on the instrument panel with two ¼" bolts. It shows the operating condition of engine, and gives positive protection.

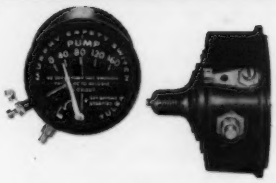


For Battery Ignition Tractors and Engines
Add No 117 Magnetic Ignition Switch

To convert the above basic panel for battery ignition engines, simply add the No. 117 magnetic ignition switch shown at the left.

For Diesel Tractors and Engines Just Add No. 117 and Solenoid Valve

. . . and for POSITIVE Protection if Water Supply Fails



If water supply fails or couplings part, here is complete protection.

Combination water pressure gauge and automatic water failure switch in one low cost unit. Easy to install — just screw into gauge connection between pump and check valve.

PRESSURE RANGES AVAILABLE:
0 — 75 lbs. 0 — 120 lbs. 0 — 160 lbs.

Wherever there is irrigation, you will find a Murphy Dealer with a stock of switches and parts, ready to offer you service.

See Your Local Dealer or Jobber for MURPHY Switches and Repair Parts

FRANK W. MURPHY, Manufacturer
BOX 1476 TULSA, OKLA.
BRANCH: LOS ANGELES 41, CALIFORNIA

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Bancroft, Allen D.—Junior product engineer, Papec Machine Co. (Mail) Shortsville, N. Y.

Brasch, Paul R.—Manager, crop drier div., Clay Equipment Corp., Cedar Falls, Iowa

Buttfield, John K.—Sales engineer, U.K. and Dominion Motors Pty., Ltd. (Mail) The Oliver Corp., Export Div., 400 W. Madison St., Chicago 6, Ill.

Byers, James O. Jr.—Communications officer, U.S. Navy. (Mail) 2 Elliott Place, Newport, R. I.

Campen, Kenneth W.—U.S. Army. (Mail) RR 1, Monticello, Mo.

Clark, Billie C.—District rural service engineer, Alabama Power Co., P.O. Box 1349, Mobile, Ala.

Collins, Tappan — Research engineer, research development and quality control dept., Great Lakes Steel Corp., Ecorse, Detroit 29, Mich.

Crawford, Karl B. — General manager, Lorain-Medina Rural Electrification Co-op., Inc., Wellington, Ohio

Culp, Earl N.—Sales manager, export div., The Oliver Corp., 400 W. Madison St., Chicago 6, Ill.

Elema, Hindrik M.—Farm machinery expert, Technion-Israel Institute of Technology, PO Box 4910, Haifa, Israel

Feller, Ron—Assistant in agricultural engineering, Technion-Israel Institute of Technology, PO Box 4910, Haifa, Israel

Florea, James H.—Editorial director, Watt Publishing Co., Mount Morris, Ill.

Forrest, Preston J.—Assistant manager, tire design dept., U.S. Rubber Co., 6600 E. Jefferson Ave., Detroit 32, Mich.

Gutsch, N. Vincent — Planning specialist, General Electric Co., 1 River Rd., Schenectady, N. Y.

Jennings, Victor L.—Chief engineer, Cotton Electric Co-op., 226 N. Broadway, Walters, Okla.

Johnson, James B. Jr.—Junior sales engineer, Gifford-Hill-Western, Inc., 1201 Erskine Rd., Lubbock, Tex.

Jones, Dale F.—USAF. (Mail) RD 1, Latrobe, Pa.

Kelly, Patrick L. W.—Sales manager, tractor & machinery div., Queen's Bridge Motor & Engineering Co. Pty., Ltd., 31-43 Queen's Bridge St., South Melbourne, Victoria, Australia

Lindeman, Jesse G.—Engineer, product research dept., Deere & Co. (Mail) Box 526, Yakima, Wash.

McBride, J. Vincent—Chief engineer, Plastic Wire & Cable Corp., E. Main St., Jewett City, Conn.

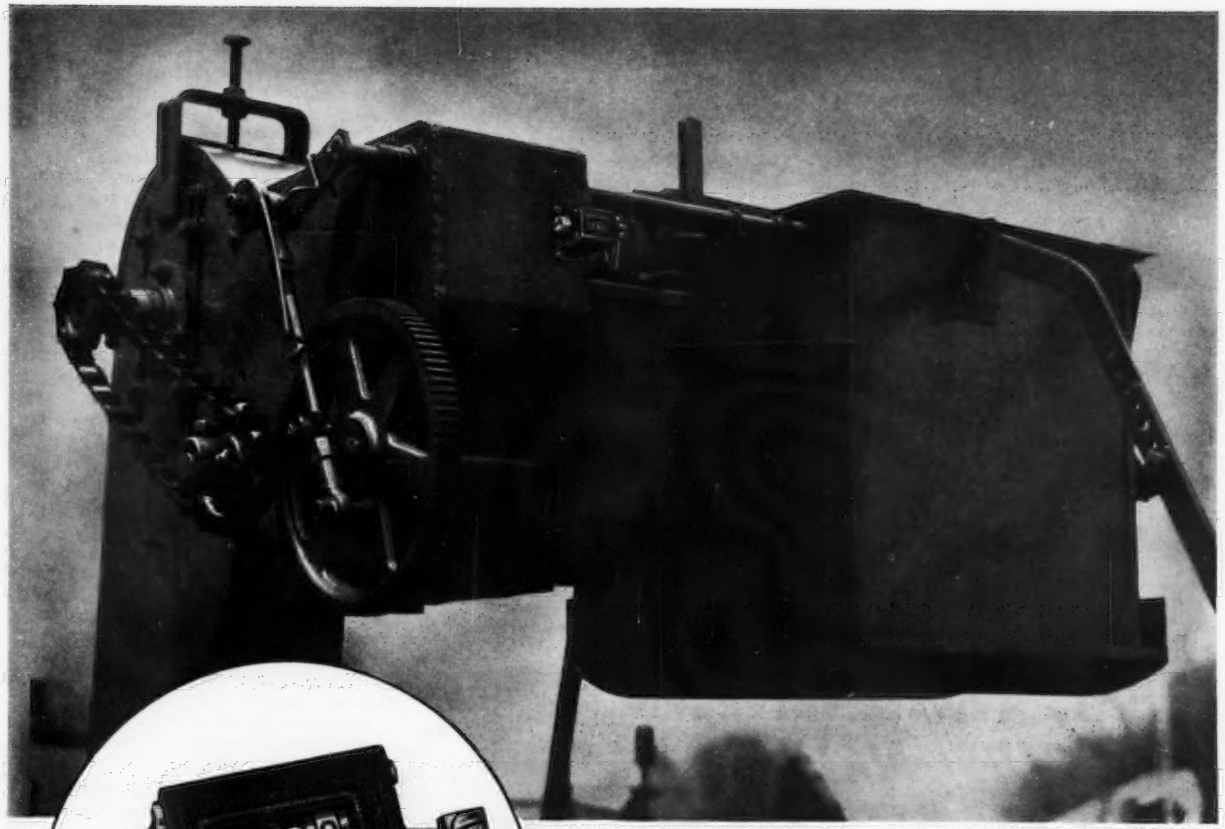
McCandless, Donald E. Jr. — Engineer (SCS), USDA, Harrisburg, Pa. (Mail) 2124 Green St.

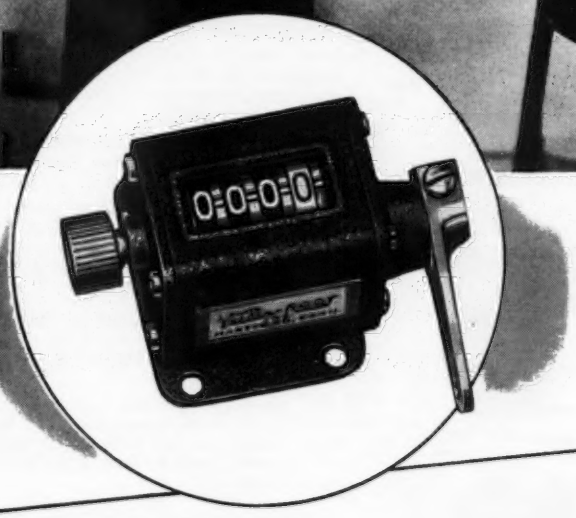
Mahaffey, Bascom—Electrification adviser, Talquin Electric Cooperative, Inc., PO Box 391, Quincy, Fla.

Maitin, Pierre E.—Soil conservation engineer, Soil Conservation Section, Dept. of Agriculture, Nicosia, Cyprus

Martin, James D. — Agricultural engineer (ARS), USDA, Clemson, S. C. (Mail) 101 Riggs Dr.

(Continued on page 552)





Combine Owners:

Here's how a built-in

VEEDER-ROOT COUNTER

helps you 4 ways!

1. **IN CUSTOM COMBINING.**
   Counts every bushel right in the field.
2. **IN SHARING THE HARVEST.**
   The accurate tally tells the yield exactly, prevents arguments between landlord and tenant.
3. **IN FARM STORAGE.**
   Permits storing or dividing grain in the correct amounts.
4. **IN YIELD VERIFICATION.**
   Helps check the use of fertilizer or the advantages of summer fallow.

For accurate counting (and cost-controlling) down on the farm, Veeder-Root makes a complete line of counters which are built into tractors, hay balers, grain drills and combines. *Get the facts* whether you make, sell, buy or use farm equipment. Write for bulletin.

VEEDER-ROOT INC.

"The Name That Counts"

HARTFORD 2, CONNECTICUT

549 WASHINGTON BLVD., CHICAGO 6 • Tel: State 2-6283

Applicants for Membership

(Continued from page 550)

Moore, Vernon P. — Cotton technologist, Cotton Ginning Laboratory (USDA), PO Box 426, Leland, Miss.

Morrill, Arthur D.—Owner, Mamco Mfg. Co., and Stromsburg Cash Lumber Co., Stromsburg, Nebr.

Myers, Franklin W.—2nd lt., USAF, Box 58, Hdq. 32nd Air Div., Syracuse A.F.S., Syracuse 6, N. Y.

Myers, Lawrence A. Jr.—Junior designer, New Holland Machine Div., Sperry Rand Corp., New Holland, Pa. (Mail) 244 Locust Ave.

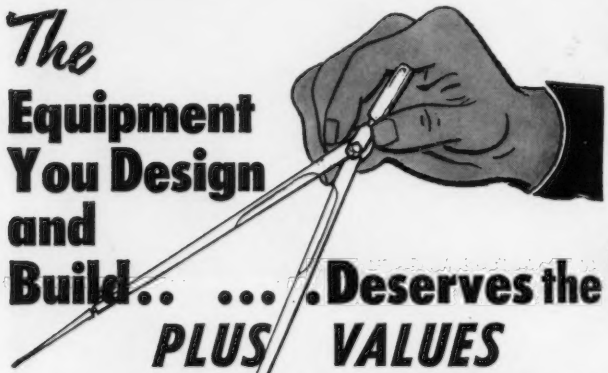
Neuhoff, Alfred L.—Research assistant and graduate student in agricultural engineering, Purdue University. (Mail) RR 3, Huntingburg, Ind.

Nicholls, Homer W.—Branch manager, International Harvester Co., 1709 E. Clay St., Richmond, Va.

Patrick, John D.—Production trainee, Ralston Purina Co. (Mail) Box 223, Clemson, S. C.

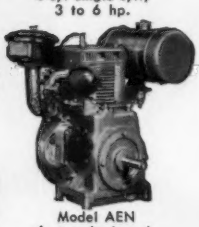
Pittman, Don N.—Test engineer, Consolidated-Vultee Aircraft Corp., San Diego 17, Calif. (Mail) 3428 Waco St., Apt. 2

Poernomo, Heroe — Graduate student in agricultural engineering, University of Nebraska, Lincoln 1, Nebr.



The Equipment You Design and Build... ....Deserves the PLUS VALUES of WISCONSIN Heavy-Duty Air-Cooled ENGINE POWER

Models ABN, AKN, 4-cy. single cyl., 3 to 6 hp.



Model AEN 4-cy., single cyl. 4½ to 8¼ hp.

Models AFH, AGH, AHH, single cylinder, 6 to 9 hp.

Models TE, TF, TFD 2-cylinder, 7 to 15 hp.

V-type 4-cylinder 15 to 36 hp. models.

Wisconsin Heavy-Duty Air-Cooled Engines offer the design engineer, power equipment manufacturer and the ultimate user the cumulative benefits of many years of exclusive specialization in the heavy-duty air-cooled engine field.

The completeness of the line, comprising 12 models in 4-cycle single cylinder, 2- and 4-cylinder types and sizes ranging from 3 to 36 hp., provides close selectivity to fit your equipment and its service applications without power waste, yet retaining maximum power advantage. The benefits of "Wisconsin Standardization" on a variety of types and sizes of your own original equipment can be important to you. Some of the "Plus Values" of Wisconsin Power include:

Heavy-Duty engineered design and construction in all details; self-cleaning, file-hard tapered roller bearings at BOTH ends of the crankshaft; an easily accessible rotary type, high tension OUTSIDE Magneto, equipped with Impulse Coupling for quick starts in any weather, at low cranking speed; pump circulated splash lubrication on smaller models and geared oil pump delivering individual oil stream to each rod on multi-cylinder models, plus efficient AIR-COOLING at temperatures up to 140°.

All this adds up to efficient Power Performance, Long Engine Life and Low-Cost Maintenance . . . factors of vital importance in relation to the operation of your original equipment.

• • •

Our Engineering Department will be glad to cooperate with you in adapting Wisconsin Engines to your equipment. Complete your data files with a copy of our 64-page "Blue Book", Form S-150, illustrating more than 250 Wisconsin Engine service applications, together with engine specifications.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

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A 8280-½I-AA

Reid, Tom P.—Research assistant in agricultural engineering, Clemson Agricultural College, Clemson, S. C.

Reynolds, John N.—Farm service consultant, Puget Sound Power & Light Co., Kirkland, Wash.

Riggs, Edwin C.—Sales manager, agriculture div., The Lennox Furnace Co., 1701 E. Euclid Ave., Des Moines, Iowa

Roberson, R. Fred—Layout draftsman, International Harvester Co., Canton, Ill.

Schreyer, Theodor E. Jr. — U.S. Army. (Mail) 292 N. Wolf Rd., Des Plaines, Illinois

Schwalm, Bruce D. — Engineering trainee, New Holland Machine Div., Sperry Rand Co. (Mail) Box 43, Honey Brook, Pa.

Shute, Milton—Instructor, Southern Illinois University, Carbondale, Ill.

Smith, Sanford N.—Assistant engineer, tractor engineering dept., Allis-Chalmers Mfg. Co., West Allis, Wis. (Mail) 1812 S. 77th St.

Smith, William F.—Sales engineer of agricultural machinery, Frederic W. Smith, Ltd., PO Box 1623, Wellington, New Zealand

Snowden, Arnold M.—Student in agricultural engineering, Oklahoma A. & M. College. (Mail) PO Box 544, Frederick, Okla.

Souther, Albe O.—Dairy division engineer, Perfection Manufacturing Corp., Minneapolis 14, Minn. (Mail) 2821 Polk St., N.E.

Swearingen, Thomas K.—Publication director, Stran-Steel Corp., Ecorse, Detroit 29, Mich.

Vorrie, Norbert J.—Applications engineer, Allison Div., General Motors Corp. (Mail) Thor, Iowa

Wagoner, Paul M. — Partner, Wagwood Farms, Gibsonville, N. C.

Watson, Robert Jr.—District sales manager, Food Machinery & Chemical Corp., John Bean Div. (Mail) 9 Vadnais St., Agawam, Mass.

Zucker, Abraham—Director, technical high school for farm machinery and guest lecturer, Technion-Israel Institute of Technology, Bank Leumi Le'Israel Ltd. (Mail) Sarid, Israel

Transfer of Membership Grade

Christen, Thomas P. Jr.—Manager of farm sales, Standard Oil Co. (Ohio), Midland Bldg., Cleveland 15, Ohio. (Associate Member to Member)

Hancock, Thomas E.—Distributor assistant general sales manager, Florida Ford Tractor Co., PO Box 1258, Jacksonville, Fla. (Affiliate to Member)

Hansen, Hugh J.—Associate editor, *Electricity on the Farm Magazine*, 305 E. 45th St., New York 17, N. Y. (Associate Member to Member)

Maramba, Felix D. — Dean of graduate studies, Araneta Institute of Agriculture and senior partner, Maramba & Associates, Precilla Bldg No. 3, 541 Rizal Ave., Manila, Philippines. (Associate Member to Member)

Shanklin, Milton D.—Agricultural engineer, Portland Cement Assn. (Mail) 349 E. Park St., Westerville, Ohio. (Associate Member to Member)

Stephenson, Kermit Q.—Instructor in agricultural engineering, University of Arkansas, Fayetteville, Ark. (Associate Member to Member)

Cessna

NELSON-RYAN AVIATION SALES, INC.
Flying Cloud Airport
ROUTE NO. 1
HOPKINS, MINNESOTA

PHONE
HOPKINS 7696

April 25, 1955

Hypro Engineering Company
404 Washington Avenue North
Minneapolis, Minnesota

Gentlemen:

We have been in the spraying business for about five years, and the main problem we must contend with is the pump and the job it must do.

For years we have experimented with various types of pumping equipment, some with a fair share of success, others poor. Breakdowns were frequent, requiring the carrying of spare pumps, and usually replacement parts. The boys would spend many an evening hour servicing the pump for the next days operation. Pumps used were bronze construction and did not last too long.

The 1954 season was extra long. During the entire 1954 season we operated two planes equipped with the Hypro 750 NiResist Pump driven by a six-bladed fan at approximately 1800 RPM. Over 250 actual hours of spraying time was logged on each of the pumps. During the entire season we did not have a pump failure or breakdown and no service was required at any time. It was a pleasing experience to us and the boys who fly our planes because we could do a job without a worry. Both pumps were factory checked for wear, and with minimum service, replacement of rollers, are now ready for use.

During the coming season we again intend to use these pumps and some new ones, as we add planes and extend our operation. We are well pleased with the Hypro 750 NiResist Pump and recommend it highly.

Very truly yours
NELSON-RYAN AVIATION SALES
Ray J. Ryan
Ray J. Ryan

How to defeat corrosion and erosion with NI-RESIST in SPRAY PUMPS

You've probably seen spray pumps that resist corrosion but fail from erosion by solid particles in the spray. And others that resist erosion but quickly fail from corrosion.

You can defeat this double attack . . . corrosion and erosion . . . by use of Ni-Resist® castings. They resist not only chemical attack, but also erosion and metal-to-metal wear (see letter above).

Write INCO for a copy of "Engineering Properties and Applications of Ni-Resist." It gives you the facts about Ni-Resist.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.

NEW BOOKS

Soil and Water Conservation Engineering by R. K. Frevert, G. O. Schwab, T. W. Edminster and K. K. Barnes. Cloth, xiii+479 pages, 5½ x 8½ inches. Illustrated and indexed. John Wiley and Sons, (440 Fourth Ave., New York 16, N. Y.) $8.00.

This is the fourth book to be published in the Ferguson Foundation Agricultural Engineering Series of texts. It covers the aspects of soil and water conservation from an engineering viewpoint. Text material has been carefully selected from multiple sources and presented in a well-organized sequence that should contribute materially to the professional training of agricultural engineers and also prove to be a valuable reference as a field manual. Chapters cover precipitation, infiltration, evaporation, transpiration, runoff, soil physics, erosion, contouring, strip cropping, tillage, vegetated outlets and watercourses, terracing, gully control, embankments, reservoirs, flood control, surface drainage, open ditches, subsurface drainage, pumps and pumping, sprinkler irrigation, land clearing, and legal aspects of soil and water conservation.

Farm Machinery and Equipment, by Harris P. Smith (Fourth edition). Cloth, ix+514 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co., 330 West 42nd St., New York 36, N. Y. $7.50.

The new edition is completely revised to bring up to date the latest developments in all types of equipment used in producing, handling and processing farm crops. A new chapter on lubricants and lubrication includes the latest API classification of engine oils. Modern methods of weed control and the application of liquid and gas fertilizers are described. Chapters cover materials of construction, mechanics, power transmission, lubricants, hydraulic power lifts, rubber tires, selection of farm machinery, tillage history, crop processing and labor-saving equipment. Also included are chapters on equipment for tillage, planting, weed control, spraying, dusting, fertilizing, and harvesting equipment for hay, forage, grain, corn, cotton and miscellaneous crops.

Electro-Technology, by M. G. Say. Cloth, 167 pages, 5½ x 8½ inches. Illustrated and indexed. Philosophical Library, Inc., 15 East 40th St., New York 16, N. Y. $6.00.

This book presents in a concentrated form the electrotechnical basis of the phenomena which are important in light and heavy electrical engineering. The material covers most of the primary circuit problems for both steady and transient states and includes a comprehensive list of definitions. Chapters cover modern conceptions of the nature of electricity; fundamental physical relations; units; resistance, electro-chemical, electric field and magnetic effects of electro-technics; circuits; circuit and network calculations; symmetrical components; transients; loci of complex functions; analogies; mathematical tables and formulas.

Proceedings of American Society for Testing Materials (Vol. 54). Cloth, xxi+1412 pages, 6 x 9 inches. Illustrated and indexed. Published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

The book is published annually and includes all reports and papers offered to ASTM during the current year and accepted by the administrative committee on papers and publications, together with discussions. The table of contents and subject and author indexes cover all papers and reports published by ASTM during the year, which also includes papers published in the ASTM *Bulletin* or in special technical publications.

Cotton Ginner's Handbook, by Tom J. Johnston. Paper, 159 pages, 6½ x 10½ inches. Illustrated and indexed. Arkansas-Missouri Cotton Ginners Assn. Inc., 1012 North 6th St., Blytheville, Ark. $5.00.

It is a compilation of useful information for quick reference intended to help ginners do a better job for the farmer. Chapters cover the effect of ginning on cotton quality, malpractices, how to get better grade cotton without fiber damage, needs and problems of the ginner, how to gin hand-picked cotton, how to gin roughly hand-harvested and machine-picked cotton, and how to gin machine-stripped cotton. One part of the book is devoted to what ginners should know about gin operation and devotes sections to the following: fans and piping, seed handling, vaporizers and heaters, seed cotton feed rate controls, moisture restoration, green boll traps, cyclones, incinerators, speeds and horsepower, servicing engines, bale weights, pink bollworm machines, conditioning and storing seed cotton, gin operator personnel, and expense-income appraisal.

A Preliminary Study of Farm Implements Used in Taiwan Province (Plant Industry Series No. 4), by Fengchow C. Ma, T. Takasaka and Ching-wen Yang. Paper, 331 pages, 7½ x 10¼ inches. Chinese-American Joint Commission on Rural Reconstruction, 25, Nenhai Road, Taipei, Taiwan, China. $5.00 ($80.00 in New Taiwan currency).

This is a report of a project "Investigation of Farm Implements in Taiwan" initiated and financed by the Joint Commission on Rural Reconstruction in 1952. The report is in two parts.

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Practical and thorough, your Rochester Sales Engineer is ready to act as your technical advisor. He is a specialist in his field, ready and well qualified to serve you. His years of experience and technical skill are yours. State your problem . . . with complete confidence that it will be solved. Your Rochester Sales Engineer is backed by the Rochester Manufacturing's competent research and production facilities. Rochester Manufacturing Company's basic designs permit custom engineering for your specific application.

Whenever you are selecting the gauges for your new models, look to the Rochester Manufacturing Company for the latest in design and dependability . . . for the best rugged service. Call in your Rochester Sales Engineer today, or write to the company for a representative to call.

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ROCHESTER DEPENDABLE ACCURACY GAUGES
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"Grassland Newsreel"

...latest hit from New Holland's film library

HERE'S entertainment and education rolled into an 18-minute motion picture, produced with sound and in full color.

Narrated by Ed Herlihy, well-known news commentator, "Grassland Newsreel" covers outstanding advances in grassland farming. Filmed for the first time by newsreel camera are stories on cold silage, zoo farms, weed farms . . . new machinery and methods that are boosting profits on U. S. and Canadian farms . . . an old-time threshing party . . . an American beauty boosting the "drink more milk—eat more meat" program.

Note to teachers: Special showings of New Holland movies can be arranged for your high school vo-ag classes. Films now available are: the new "Grassland Newsreel," "Green Promise," a 28-min. sound-color story of grassland farming, "Grassland Report," a 25-min. sound-color newsreel of farm events, 20-min. "Parade of Products" and 15-min. "March of Machinery," newsreels on modern farm machinery.

NEW HOLLAND

"First in Grassland Farming"

Drink more milk Eat more meat
for a healthy America and a strong agriculture

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School Name _____

Address _____

☐ Grassland Newsreel ☐ Green Promise ☐ Grassland Report ☐ March of Machinery
☐ Parade of Products

NEW BULLETINS

House Building by Farm Owners in North Carolina, by James W. Green. North Carolina Agricultural Experiment Station (Raleigh) Bulletin 391 (September 1954) This unusual bulletin reports not on structural details and methods, but on human motives and processes in deciding to build, what features are wanted and how to get the job done. A condensation of an unpublished PhD thesis, it reports on the objective and method of the study, builders and their families, the new farm houses, why farmers build, delays and sacrifices in building, seasons of building, planning the farm house, contracting procedures, collecting building materials, use of labor, financing conclusions and implications, and floor plans.

NIAE Bulletins. The following bulletins have been received recently from the National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire, England.

NIAE Experimental Grain Cleaner No. 7—Report No. 45.

Grain Storage in Outdoor Silos (1952 to 1955)—Report No. 47.

The Effect of Drum Setting and Crop Moisture Content on the Germination of Combine Harvested Wheat—Report No. 51.

The Measurement of Heat Flow in Soil With Reference to Glasshouse Heating—Technical Memorandum No. 111.

The Drying of Blue Peas — Technical Memorandum No. 118.

Agricultural and Horticultural Engineering Abstracts—Vol. VI, 1955, No. 2.

Proceedings of the Third Annual Dairy Engineering Conference by Carl W. Hall and A. W. Farrall. The 79-page bound report contains copies of papers given at the Third Annual Dairy Engineering Conference held at Michigan State University, March 8 to 9, 1955. (Price, $1.50). Subjects of papers covered dairy waste treatment; preventive maintenance for processing equipment; bulk milk vending equipment; dollars saved by vehicle sense; refrigerated trucks; dairy industry engineering innovations; work sampling; cold sterilization; new equipment; dry milk fat; temperature measurement and control, and concrete floors for the dairy plant.

Planning Farm Water Systems, by G. E. Henderson, coordinator, and illustrated by C. E. Turner of the Southern Association of Agricultural Engineering and Vocational Agriculture. A 76-page booklet covering all the factors involved in planning and installing a complete farm water system. Illustrations, graphs, tables and examples help to present the valuable information. Sections cover daily water requirements, water sources, pump capacities, pump types, accessories, protection of water sources, pipe installation, size and kind of pipe, and wire and motor protection. (Copies are available from Coordinator's Office, Barrow Hall, Athens, Ga. Price $1.00 per copy.)

Seepage Losses from Irrigation Ditches On The South Plains Of Texas, by Charles T. Bourns, Texas Technological College (Lubbock). A 21-page bulletin reporting on studies of seepage losses made by measuring the difference between the inflow and outflow in irrigation ditches located in various of the principal soils found on the South Plains.

Planning Stall Barns, by L. A. Brooks, E. G. Bruns, F. W. Duffee, M. J. LaRock, L. G. Morrissey, F. S. Moulton, C. H. Neitzke, and S. A. Witzel. Agricultural Experiment Station (Madison) Special Bulletin 4 (October 1954). A 64-page bulletin containing all the principal design factors involved in planning and constructing stall-type dairy barns. Plans for new barns as well as plans for remodeling old barns are included.

Frost Determination by Electrical Resistance, by Elmer F. Rowland, Lowis H. Stolzy and George A. Crabb, Jr., Michigan Hydrologic Research Station (East Lansing). A reprint from Bulletin 100, Highway Research Board, Washington 25, D.C., describing a new method of determination of frost in the soil profile in situ. The method involves interpretation of electrical resistances obtained with a soil-moisture block and their associated soil temperatures.

Studies of Airplane Spray-Deposit Patterns at Low Flight Levels, by Joseph C. Chamberlain, Charles W. Getzendaner, Harold H. Hessig, and V. D. Young U.S. Department of Agriculture Technical Bulletin 1110. A 45-page, illustrated bulletin reporting on results of research studies made in the development and improvement of methods of controlling insects on vegetables and related truck crops with insecticides applied by aircraft. Copies are available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price 25 cents.

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Wheels Engineered for the Job
WRITE US FOR RECOMMEN-DATIONS
Rear Tractor Wheel for Demountable Rim
Planter Press Wheel—one piece rim with or without rubber tire
Pick-up Wheel Crown-face Steel Rim
Rear Tractor Wheel Reversible
Combine Wheel Reversible
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ELECTRIC WHEEL COMPANY
2802 SPRUCE · QUINCY, ILLINOIS

Most powerful of all!

5-6 PLOW OLIVER SUPER 99 GM DIESEL

Never before so *much* power in a general-purpose farm tractor—a full 72 horsepower on the drawbar, 80 on the belt!*

And all this power comes from a diesel engine entirely different in principle—now offered for the first time in a farm wheel tractor that's factory built.

It's one of the most popular and widely known engine types made—a famous General Motors diesel in use right now by the thousands on more than 750 different kinds of power jobs everywhere in the world.

You can be sure of it—here's *real* power! Because *every* down stroke of every piston is a *power* stroke! That's one important way the Super 99 GM differs from other tractors. And that's why it won't slow up under sudden load changes, why it surges ahead instantly—with amazing smoothness—at a touch of the throttle. Because it's a 100% diesel, operation costs are only a few pennies per acre.

The Super 99 GM Diesel is a new concept in farm tractor power that offers many other design advancements as well—like six forward speeds ...big, flat platform... rubber-spring seat and double-disc brakes—features that increase performance and productivity, and make operation easier and safer.

The OLIVER Corporation
400 W. Madison St., Chicago 6, Ill.

*Corrected horsepower ratings observed during manufacturer's tests.

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"FINEST IN FARM MACHINERY"

You Can't Beat

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FOR BEST VALUE, buy *Grade-Marked* sheets, which show weight of zinc coating. And for longer, stronger service, specify heavy-coated roofing and siding such as the "Seal of Quality" . . . With *galvanized* sheets, you get the *strength* of steel, the *protection* of zinc. Preferred by thousands of users. Proved by time itself. Feature by feature, they're your *best buy*. Check and compare with any other material!

ZINC INSTITUTE 2 OZ. COATING SEAL OF QUALITY

	GALVANIZED SHEETS	ANY OTHER MATERIAL
STRUCTURAL STRENGTH and rigidity; withstand rough treatment	YES	
YEARS OF RUST-FREE SERVICE; little or no upkeep problems	YES	
EASIEST TO HANDLE, lay and nail; stay put, hold at nail-holes	YES	
LIGHTNING PROTECTION, fireproof, ratproof, pleasing appearance	YES	
LOW COST ALL THE WAY, to buy, to apply and thru the years	YES	

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PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN—JANUARY—O-437-667, 438-668, 447-672. FEBRUARY—O-19-704, 32-705, 33-706, 18-709. MARCH—O-55-710, 61-713, 71-714, 87-715. APRIL—O-120-716, 125-718, 155-719, 143-720, 173-721. MAY——O-200-722, 197-723, 180-724, 196-725, 205-726, 214-727, 214-728. JUNE—O-244-731, 268-732, 248-733. JULY—O-267-734, 289-735, 297-736, 298-737, 303-738, 307-739, 316-740.

POSITIONS WANTED—APRIL—W-114-8, 4-10. MAY—W-176-19, 206-21, 182-22. JUNE—W-179-24, 203-25, 247-27, 250-28, 252-29, 245-30, 263-31, 208-32. JULY—W-225-34, 266-35, 295-36, 265-37.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEER for design, development and research in rural electrification as applied to agricultural product marketing problems in the Southwest, with federal agency. BS deg in agricultural engineering, or equivalent. One year research experience. Interest in farm electrification and marketing research, plus usual qualifications for public service. Opportunities normal to engineers under federal Civil Service. Limited opportunity for graduate study. Opening effective immediately. Salary $4300-4850. O-305-741

SALES ENGINEER representative in eastern states for western manufacturer of sprinkler irrigation equipment. To contact, cultivate, and service distributor accounts. Location probably within 200 miles of Atlanta, Ga. Age 25-50. BS deg in agricultural engineering preferred but not essential if other qualifications are good. Should be well acquainted with irrigation field and have experence in contacting organizations and people interested in the practice. Good personality and ability to get along well with people. Unlimited opportunity. Salary open; salary, commission and expense basis. O-319-742

AGRICULTURAL ENGINEER (instructor rating) for full-time research in soil and water field, at an accredited midwest land grant university. BS deg in agricultural engineering, MS preferred. The man selected would be expected to work toward an advanced degree. Excellent cooperation with other departments and experiment station, well recognized department and engineering college. Good facilities and opportunity to develop a fine research program in soil and water. Responsible for direction of research assistants and technicians, planning and execution of an active research and development program. Salary about $4000, one month vacation, with the opportunity for excellent advancement upon completion of advanced degree. O-325-743

AGRICULTURAL ENGINEER for research in cotton mechanization (⅔ time) and teaching farm power and machinery professional and service courses, in a land grant college in the Southwest. MS deg in agricultural engineering, or equivalent, and several years research and teaching experience in field. Must furnish adequate references. Opening for 2-yr period to replace staff member going on foreign assignment. Position may be made permanent under expanded research program. Personnel retired from other educational work on age basis will be considered. Annual leave, 24 working days. Opening available immediately. Salary, $5580 to 7476, depending on qualifications. O-329-744

AGRICULTURAL ENGINEERING research fellowship for work in high frequency radiation effects on seeds, in a southeastern state university. Half-time on work toward MS deg. BS deg in agricultural engineering, or equivalent, with "B" average or better, and 2 or more courses in electrical field in addition to physics. Usual personal qualifications for work toward advanced degree. Excellent opportunity for man interested in electricity to participate in development of a new field that appears to have unlimited possibilities. Research material may be used as basis for thesis. Should be able to complete requirements for MS deg in 2 years. Salary $1800. O-334-745

AGRICULTURAL ENGINEER (instructor or assistant professor rank) for teaching and research in farm buildings and metalwork in a southeastern state university. BS deg in agricultural engineering. Young man with armed services record and building experience. May work toward MS deg and financial advancement. Research ¼ time. Data may be used in thesis. Salary open. O-334-746

AGRICULTURAL ENGINEER (junior or intermediate vocational instructor) to teach courses in farm machinery, farm tractors, and rural electrification to agricultural engineering majors and students from other agricultural departments in a western state college. Age 25-45. BS or preferably MS deg in agricultural engineering, or equivalent. Good personality; ability to cooperate and get along well with others; initiative and imagination to develop an outstanding program. Farm background. Work in tractor or implement business; teaching in agricultural engineering or vocational agriculture; or research experience in farm equipment. Excellent opportunity in schools with large laboratory farm, growing enrollment and new facilities being added. Position open Sept. 1. Salary $4093-5712 for academic year. O-338-747

AGRICULTURAL ENGINEER for extension work in farm mechanization and farm structures fields in a western state. BS deg in agricultural engineering, or equivalent from an accredited department. Extension or related experience desirable. Must be able to cooperate and work closely with teaching and research staff in preparing extension publications and work programs. Salary open, depends on training and experience. O-345-748

AGRICULTURAL ENGINEERING research fellowship in farm structures in land grant college in Southwest. Usual graduate study program for MS deg in agricultural engineering, plus assistance in research on farm structures design and equipment. BS deg from an approved 4-yr curriculum, with above average scholastic record. Good health. Initiative and dependability. Farm background desirable. Assignment for 10 to 12 mo, depending on course requirements and progress of individual. Effective Sept. 1. Salary $1500 for 12 mo. O-346-749

AGRICULTURAL ENGINEER (instructor) to teach irrigation, soil conservation, and farm power in land grant college in the Southwest. BS deg in agricultural engineering. MS deg desirable but not essential. Good scholastic record. Farm background preferred. Teaching experience desirable but not required. Good health, initiative, and dependability. Reasonably good speaking ability and personality. Limited graduate work may be taken by man not having MS deg. Effective Sept. 1. Salary open. O-346-750

AGRICULTURAL ENGINEER (instructor or assistant professor) for teaching farm machinery and research in cotton mechanization in a southwestern land grant university. Position is jointly in college of agriculture and agricultural experiment station. Age. 26-38. MS deg or higher in agricultural or other branch of engineering from recognized school of engineering. Preferably 3 to 4 yr experience in farm power and machinery field. Interest in agriculture and the application of engineering principles to the solution of agricultural problems. Ability to deal with public, cooperate with associates, and conduct research. Research program due to continue and be enlarged. Position now open. Retirement plan. One month vacation. O-347-751

AGRICULTURAL ENGINEER for teaching and research, primarily in rural electrification, but with some work in farm structures, in a land grant university in the Southeast. No age limit. MS deg in agricultural engineering, or equivalent, preferred. Well qualified man with BS deg will be considered. Experience in field desirable. Usual personal qualifications for public service work. Provision can be made for limited graduate work without reduction in salary, if man selected lacks MS deg, so it can be obtained in a few years. Opening effective Sept. 1. Salary open. Can be made attractive to well qualified man. O-350-752.

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for design, development, research, sales, service, or management in power and machinery field with public service, manufacturer, or farming operation. Any location, some preference for Midwest. Will travel part time. Married. Age 31. Vision corrected by glasses. BS deg in agricultural engineering, 1950, University of Illinois. Farm background. Retail farm equipment sales experience summers while in college. USDA cotton ginning research 3 yr. Product test engineer, present position, 2 yr. Enlisted service in USMC, 2 yr. Available on reasonable notice. Salary open. W-308-38

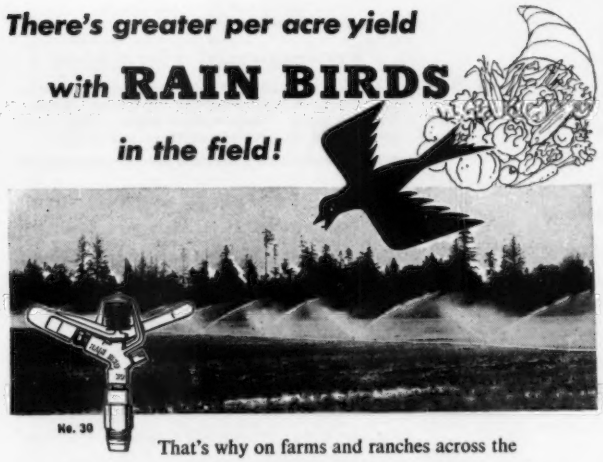
AGRICULTURAL ENGINEER for design, development, research, extension, or writing in farm structures or soil and water field, with manufacturer or consultant, anywhere in USA. Some foreign locations acceptable. Willing to travel occasionally. Married. Age 25. Slight limitation in use of right forearm. BS deg in agricultural engineering, 1951, Texas A & M College. Farm background. One year with construction firm in design and drafting. SCS in irrigation and drainage, 2 yr. Exploration survey with seismograph crew, for oil company, present position, 18 mo. Available Aug. 25 or on 2 weeks notice. Salary open. W-318-39

AGRICULTURAL ENGINEER for design, development, research, sales, or service in power and machinery field, in private enterprise or public service. Southeast or California preferred, but will work anywhere in USA, or in foreign location where wife can accompany. Married, Age 26. No disability. BS deg in agricultural engineering, 1952, North Carolina State College. Farm background. Farm tractor sales, 5 mo. US Naval Reserve officer on active duty since June 1952, as communications officer on a destroyer. Available November 1. Salary, $4000. W-312-40

There's greater per acre yield

with RAIN BIRDS

in the field!



No. 30

That's why on farms and ranches across the nation . . . around the world, you'll find more RAIN BIRDS than any other type sprinkler.

Made with a minimum of moving parts to wear or require servicing, RAIN BIRDS stay on the job, performing day in and day out with maximum efficiency and dependability.

Remember, if it hasn't the name . . . it isn't the same. Specify RAIN BIRD!

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Always use . . .

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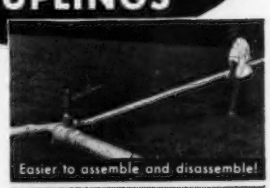
No Hooks, Latches or Gadgets



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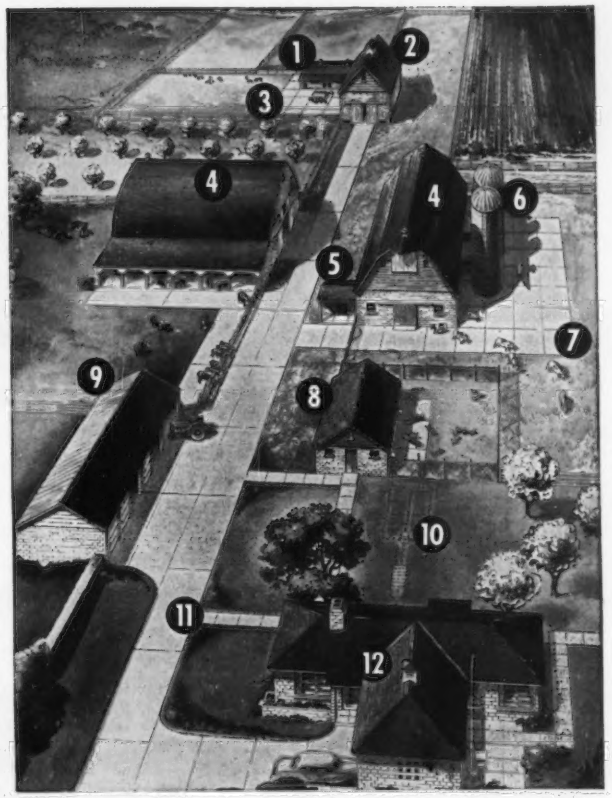

Help Farmers Increase Profits with These Concrete Improvements

The above drawing shows 12 important farm improvements that agricultural engineers can design to help reduce work and increase production for their farm clients. Concrete improvements soon pay for themselves, yet continue to return dividends year after year.

Concrete is moderate in first cost, requires minimum maintenance and gives a lifetime of ***low-annual-cost*** service. Durable concrete resists damage from decay, termites, rats and storms. It reduces the ever present danger of disastrous farm fires. *Concrete can't burn.*

Yes, you perform a real service when you design concrete farm improvements.

FREE BOOKLETS on these improvements will be sent on request. Distributed in the U.S. and Canada only. Address department A8-1.

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2. CRIBS AND GRANARIES
3. FEEDING FLOORS
4. DAIRY BARNS
5. MILK HOUSES
6. SILOS
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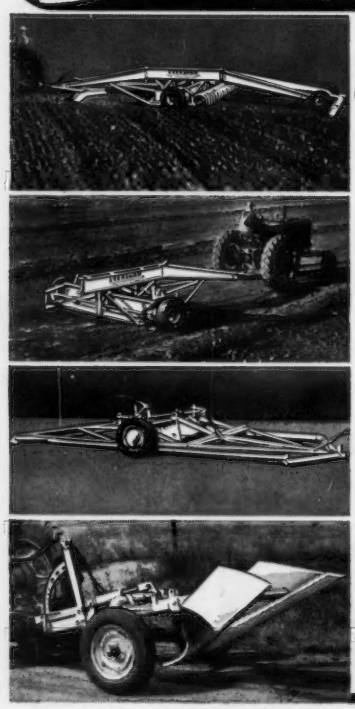
Plan Now To Do Important Leveling and Grading Work THIS FALL



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See the New EVERSMAN Hydraulic Models 9H and 12H

Now two efficient, fast operating and economical hydraulic models have been added to the Eversman line, making six models in all for standard farm tractors. Springtooth attachment available. Write for FREE booklet.

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NEWS SECTION

(Continued from page 538)

Ninth Cotton Mechanization Conference

THE 9th annual beltwide cotton mechanization conference will be held at Texas A & M College, College Station, Texas, September 7 to 9. "Mechanization—Cost and Quality" has been selected as the conference theme.

Registration will begin 4:00 p.m. Tuesday, September 6, and the conference officially opens with a welcome address 10:00 a.m. Wednesday. The tentative program includes many interesting and timely topics. Papers and talks will be given on such subjects as: the challenge of mechanization; farm research and education expansion; farm equipment industry's program; USDA-land grant college research programs; mechanical strippers and effects on cotton quality; planting methods and spacing, and cotton quality preservation.

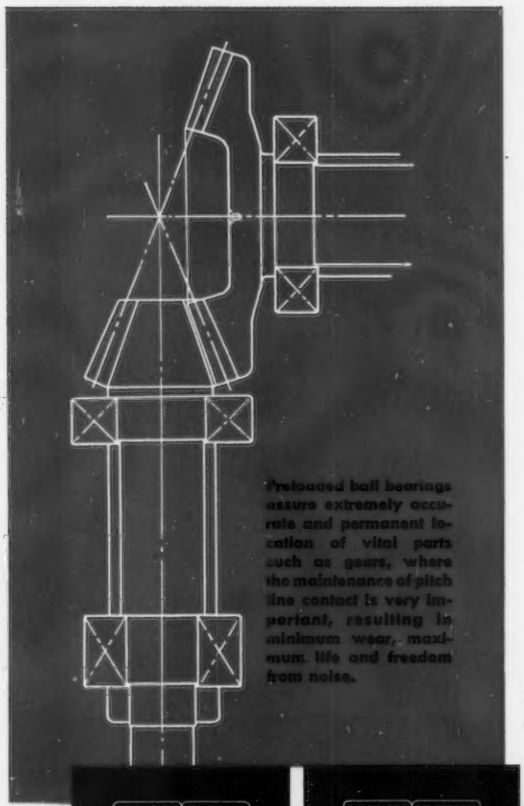
Thursday morning beginning at 9:00, a panel will discuss the physical, biological and economic aspects of cotton irrigation in the rain belt. A tour of Texas A & M's nearby principal cotton research facilities and a demonstration of experimental equipment, including stalk disposal units, are planned for Thursday afternoon.

The final day of the meeting will offer a tour to Lankart seed farm and Temple experiment station in the morning and a mechanized demonstration at Temple experiment station featuring defoliation, desiccation and stripper-type harvesting.

FACTS

about

NEW DEPARTURE
BALL BEARINGS



Preloaded ball bearings assure extremely accurate and permanent location of vital parts such as gears, where the maintenance of pitch line contact is very important, resulting in minimum wear, maximum life and freedom from noise.

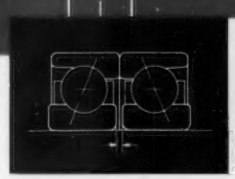
How Preloading Pays Off in Accuracy!

New Departure pioneered preloading to give you a new measure of machine accuracy! This accuracy, due to increased bearing rigidity, pays off in high-precision machines, where the slightest deflection caused by work loads on moving parts can be crucial to the ultimate performance of the machine.

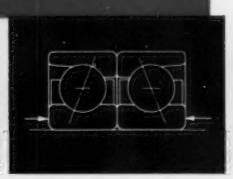
By placing a predetermined internal load on the bearing, either at the time of manufacture or at installation, deflection due to the work load is greatly reduced. This means not only that machine accuracy is greatly improved, but that the ball bearing characteristics of low torque operation and long life are fully retained.

If you are seeking a solution to your bearing problem, call on New Departure for the answer. You will benefit from more than 50 years' experience in bearing design, testing and manufacture.

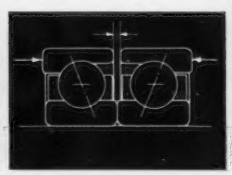
Send for Booklet BA-11 on ball bearing application



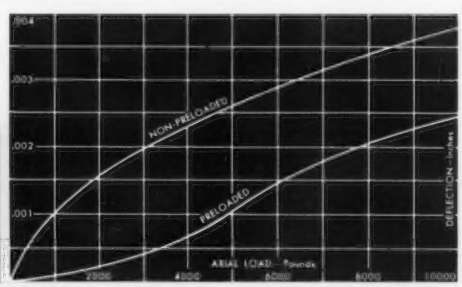
Preload is predetermined, then accurately obtained by grinding Duplex bearing faces so that an exact and fixed compression will take place when mounted.



A Duplex bearing, in effect, becomes a preloaded double-row bearing capable of holding parts within close limits, both radially and axially.



Duplex bearings may be mounted in several different ways to suit load conditions. In each case, extra rigidity of shaft centering is obtained by preloading.

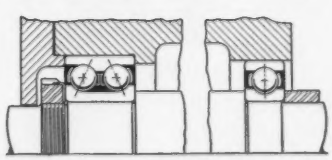


The benefits of preloading can be seen from this deflection curve. The double-row ball bearing referred to here is the most rigid type of unit bearing made to resist loads from any direction.

Typical Application of New Departure Preloaded Ball Bearings

The extreme resistance to deflection and the freedom from wear offered by the New Departure double-row bearing make it a favorite wherever exact location of parts under combined loads must be assured not only initially, but throughout long usage.

In this typical application the double row, solidly supported against suitable housing and shaft shoulders and with a "floated" single row at the other end, provides one of the best general-duty mountings where considerable thrust is present.



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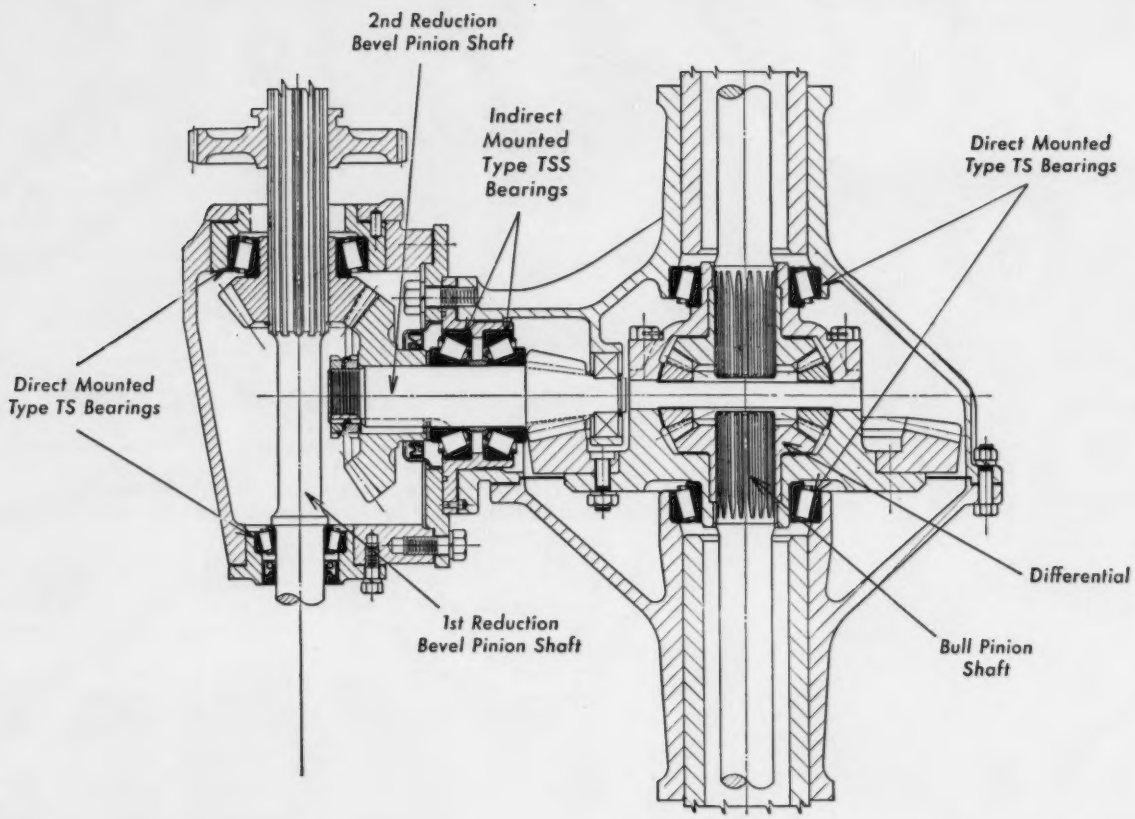
How Timken Bearings Help John Deere Whip Combination Radial and Thrust Loads in Double Reduction Axle


2nd Reduction Bevel Pinion Shaft
Indirect Mounted Type TSS Bearings
Direct Mounted Type TS Bearings
Direct Mounted Type TS Bearings
Differential
1st Reduction Bevel Pinion Shaft
Bull Pinion Shaft

HOW would you whip combination loads in gearing a combine down to less than 1-mph for rice field work? John Deere engineers did it by mounting all shafts of the double reduction axle in their No. 55 Self-Propelled Combine on Timken® tapered roller bearings.

Each shaft carries at least one bevel gear. Timken bearings easily handle the resulting combination radial and thrust loads without special thrust bearings. The tapered construction of Timken bearings enables them to take *any* combination of radial and thrust loads.

Because Timken bearings hold housings and shafts concentric, seals are more effective. There's no shaft wobble. Lubricant stays in—rice field mud stays out.

Timken bearings normally last the life of the combine. One reason: they're made out of the world's finest bearing steel—our own. It's an extra quality control that no other bearing manufacturer can give you.

For additional interesting information about Timken bearings, write now for your free copy of "Tapered Roller Bearing Practice in Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian Plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

The farmer's assurance of better design

Tapered Roller TIMKEN BEARING EQUIPPED

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ↕ AND THRUST →◎← LOADS OR ANY COMBINATION